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On the Conducting Paths between the Cortex of the Brain and the Lower Centres in relation to Physiology and Pathology. By D. J. Hamilton, M.B., F.R.C.S.Edin., F.R.S.E., Professor of Pathology, University of Aberdeen. (Plates XIV., XV.)

(Read 31st January 1887.)

Methods.—The great difficulties heretofore encountered in investigating the course of nerve fibres in the brain have been, firstly, the want of a method of preparation by which their gross anatomy could be thoroughly exposed, and, secondly, the failure of any previously known process of staining to satisfactorily indicate their direction on microscopic examination. In endeavouring to collect reliable data from the records of lesions of the human brain, it becomes only too evident that until more efficient methods of localising lesions be adopted than those generally in use at the present day, little can possibly be added to the knowledge we already possess.

The methods of preparation I now employ for demonstrating the connections of the brain are chiefly the *gelatine-potash* process I formerly described in the *Journal of Anatomy and Physiology* (vol. xix., 1885, p. 385), along with a modification of Weigert's hæmatoxylene-copper stain for medullated nerve fibres lately published by me in the same periodical (vol. xxi., 1887, p. 444).

The former method is suited solely for naked eye observation. The main objection to Weigert's stain is, as mentioned by its author, that it cannot be adapted to cutting the tissue in the freezing microtome. The modification above referred to has been introduced with the view of overcoming this. The reaction of the nerve-medulla is quite as intense if not more so than that obtainable by the original procedure.

Could one unite the aniline-black stain of Sankey and Lewis for nerve cells with this modification of Weigert's stain for nerve fibres, little would remain to be desired for microscopic demonstration. The difficulty, however, is that the aniline-black dye will give its proper reaction only when the brain is perfectly fresh, whereas the hæmatoxylene will act upon the nerve-medulla only when it has been hardened in a chrome salt. I have, however, already managed to partially combine the two, and see no insuperable barrier to complete success.

The Callosal Fibres.—It is, I think, almost universally believed at the present day that the corpus callosum is a commissure; that anatomically it unites equivalent areas in the two cerebral hemispheres, and that physiologically it serves to bring these into functional harmony. Some years ago, when working at the pathology of the brain, I came upon certain appearances which tended to shake my belief in the commissural theory, and which led to an inquiry, part of the results of which is embodied in this paper. The appearances alluded to are to be seen in the brain of any mammal when it has been hardened in Müller's fluid, but best in those in which the organ is of large size, as in Man. It was in Man that I first noticed the appearance, but I have since then found that it exists in all the mammalian brains I have examined. The Müller's fluid, in the case of a large brain such as that of Man, must be injected from the main vessels at the base in order to insure that it will penetrate deeply and in sufficient quantity.

If such a brain, when completely hardened, be simply cut into a series of perpendicular transverse segments, each of about half an inch in thickness, the following can be readily seen with the naked eye or with a simple lens:—

Coming out of the corpus callosum at each side is *a large arched* *mass of fibres* (see Pl. XIV. fig. 1), which leaving this body and continuous with it turns upwards, outwards, and downwards in the centrum ovale. The arcuate mass varies somewhat in shape at different parts of the brain. Thus, anteriorly it represents an almost complete semicircle, while posteriorly it becomes more pointed. The fibres entering into the composition of the arched mass subsequently pass into the inner and outer capsules. The greater bulk of them, however, enters the inner capsule, and in its anterior limb the capsule is almost entirely composed of them; while a considerable portion also seems to run into the outer capsule, constituting the inner of the two layers of which it consists. Their further course and attachments to underlying parts will be subsequently considered.

In a former paper (*Journal of Anatomy and Physiology*, vol. xix., 1885, p. 385) I have named this mass of fibres the "crossed callosal tract"; and as all my work since then has tended to fully bear out the view I at that time entertained of its significance, I propose still to adhere to this nomenclature.

In order to get at once to the gist of the arguments I intend using to explain the nature of this crossed callosal tract, I shall start with the postulate that it is mainly composed of callosal fibres which have arisen from the cortex, which have crossed in the corpus callosum, and which, instead of turning upwards to become attached to points in the opposite cortex corresponding with those from which they sprang, are now turning downwards into the two capsules to become subsequently united to the basal or other ganglia presently to be enumerated.

If it be true that the crossed callosal tract represents the fibres derived from the opposite cortex, which have passed over in the corpus callosum, and which are now turning down to the two capsules, the following data ought to admit of verification :—

1. The crossed callosal tract ought to be capable of being dissected out;
2. It ought to be co-extensive with the corpus callosum; and
3. It should be possible to trace the fibres microscopically as they turn downwards.

I shall consider each of these in order.

1. Foville long ago ("Traité complet de l'Anatomie, de la Physiologie, et de la Pathologie du Système Nerveux Cérébro-spinal," *Atlas*) showed that an arched ridge of fibres could be exposed by simple dissection turning downwards at each side of the corpus callosum, and figured appearances which, allowing for a certain amount of artistic embellishment, substantially represent what actually exists. (The author here exhibited a brain, previously hardened in Müller's fluid, in which this dissection had been made, and in which the arcuate mass of fibres was distinctly displayed. He further showed this arcuate mass in horizontal sections prepared by his gelatine-potash method, in which it was quite clearly mapped out. Its fibres had a more or less transverse direction, so that they contrasted with those coming from the cortex, and the outer border of the mass where they turn downwards was quite sharply differentiated. The fact that the arcuate mass is seen on horizontal section completely does away with the notion that Foville's dissection was artificial. In a series of horizontal sections the crest of the ridge was found to correspond in position with that in the dissection, the site of it being at a point considerably below the level of the cortex at the vertex.)

2. That the crossed callosal tract is co-extensive with the corpus callosum can be proved by dissecting it out, or by examining it in a horizontal gelatine-potash preparation.

3. To trace microscopically the fibres curving downwards from the corpus callosum is not such an easy matter as might be supposed, owing in great part to the fibres running in different planes between their points of origin and insertion.

Meynert has alleged that he could trace single fibres from the cortex of one side through the corpus callosum into the cortex of the opposite. For my own part I can hardly credit this statement, for, after having spent an immense deal of labour upon the subject, and working with methods far more refined than those employed by Meynert, it has never been my good fortune to follow a single axis cylinder from the one side to the other even in the smallest mammals. The fibres diverge and run so obliquely after crossing that I question if a section made in any one plane would suffice to expose their entire course.

If the brain be cut *perpendicularly in an oblique antero-posterior* *direction*, however, the bundles of callosal nerve fibres can be traced from about the middle line continuously down to *the outer and inner capsules, instead of upwards to the cortex as generally asserted.* In Pl. XV. fig. 2 I have given an accurate drawing of a section of the human brain (× 10 diams.), stained and prepared by my modification of Weigert's method, and taken from a region corresponding to the front of the basal ganglia. The parts of the preparation included in the drawing are the tectorial part of the corpus callosum (*c.c.*), the crossed callosal tract (*c.c.t.*), the plexiform nucleus (*p.n.*),* the head of the caudate nucleus (*c.n.*), and the inner capsule (*i.c.*). The section from which the drawing was taken was made perpendicularly in the oblique antero-posterior direction just indicated. By so doing the continuity of a certain number of callosal fibres, as will be noticed, can be followed in a direction downwards, although it will be remarked that even here some of them (as at *s.c.f.*) have been obliquely divided.

From the drawing it is evident that the bulk of the fibres issuing from the side of the tectorial part (*c.c.*) of the corpus callosum sweep distinctly upwards, outwards, and downwards towards the inner capsule (*i.c.*). They are united in coarse bundles, and thus can be readily distinguished from those entering it (*v.c.f.* and *p.n.f.*), which, although in bundles, are less condensed, and which, moreover, spread out in a radiate or fan-shaped manner. When the brain is cut in a perpendicular *transverse* direction the continuity of these fibres cannot be seen, because they have been severed by lying at an angle to the plane of section. Hence it is, I believe, that they have remained so long unnoticed. In no case have I been able to see a single bundle of fibres run upwards after emerging. After having crossed, the whole mass seems to turn downwards to the capsules, and to form the greater part of their bulk.

In two late numbers of *Brain* (vols. viii. and ix.), Dr Beevor has taken exception to this view as originally enunciated by me in a communication to the Royal Society (*Proceedings*, No. 230, 1884), and in papers which I subsequently published in the *Journal of Anatomy and Physiology* (*loc. cit.*), in *Brain* (vol. viii., 1886, p. 145), and elsewhere. He says that in the marmoset he has been unable to see the fibres turning downwards in the manner I have described, and gives a drawing which he considers demonstrates that my view is wrong, and that the old idea of the fibres passing from cortex to cortex is correct.* He asserts that this drawing is not a diagrammatic scheme, but an actual representation of a preparation in his possession. He further states that he has made oblique sections as I had directed, but still has been unable to see what I described.

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* For description of this body see the sequel.

When I read this criticism, I felt certain of two things: first, that Dr Beevor had not examined preparations cut in the oblique direction I have recommended; and, secondly, that the drawing above referred to was not an actual representation of the preparation from which it was said to have been taken. I was convinced that what he had endeavoured to depict consisted in reality of the fibres *passing into* the corpus callosum, and that he had entirely failed to see, as had happened to others, those which were *issuing from it*, owing to his having cut the brain transversely instead of obliquely. In justice to Dr Beevor's statement, however, I resolved to see his preparations for myself, and to hear his explanation of them by word of mouth. I am constantly being reminded by so-called critics that they are still sceptical of my statements, and the most ardent are those who have never taken the trouble to examine my work, nor really to work at the subject for themselves. The matter is not one which can be settled in an offhand manner, but requires the most careful scrutiny. If it had been easy to demonstrate what I have recorded, it would long ago have been done.

My anticipations in regard to the basis on which Dr Beevor's criticism was founded were more than realised. I emphatically state that the drawing of the corpus callosum given in his critique in *Brain* (vol. ix.) is very far from being an actual representation of the preparation from which it was taken. The continuity of the fibres is not such as he depicts, for immediately at the outer margin of the corpus callosum there is a break in the preparation caused by a large number of fibres having been cut off abruptly, which is not represented in the drawing. The fibres so cut across constitute those I have described as turning downwards. They have been severed, because they do not lie in the same plane as those entering the body. I further found that the oblique preparations he employed had been cut in an entirely wrong direction, in a direction which was calculated to divide the crossed callosal fibres, instead of rendering them more apparent. As I have elsewhere stated, he has not followed the directions I have so explicitly given in various of my published papers, and hence it is useless to argue the point. If he will harden the human brain, or, say, that of a sheep, by the method I have recommended, and cut this perpendicularly in an oblique antero-posterior direction, he will see what I have described. It is impossible, as I have already indicated, to trace individual axis-cylinders throughout their entire course, but the continuity of individual bundles between the corpus callosum and the capsules can be demonstrated with facility. The difficulty of tracing the course of the crossed callosal fibres rests in this, that *those which lie anteriorly after crossing run obliquely backwards, while those which lie posteriorly run obliquely forwards*, the point to which they all tend to converge being the knee of the inner capsule.

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* Ferrier, I find, has somewhat hastily reiterated this statement in the latest edition of his work on the *Functions of the Brain*.

It consequently happens that in whatever plane the organ may be cut, the fibres will be divided at some point. In a completely transverse perpendicular section the crossed callosal fibres are usually divided, and being represented only by small fragments, are very apt to be overlooked in the dense mass of nerve-medulla lying in their neighbourhood.

The Cortical Plexuses.—Of late years a good deal has been written of the most interesting plexus of medullated fibres which exists in the cortex of the cerebellum and cerebrum, by Exner (*Sitzungsb. d. k. Akademie d. Wissensch.*, vol. lxxxiii. Ab. iii., Feb. 1881), Butzke (*Arch. f. Psychiatrie*, vol. iii., 1872), Gerlach (*Centralb. f. d. med. Wissensch.*, 1872, p. 273), Boll (*Arch. f. Psychiatrie*, vol. iv., 1874, p. 1), Rindfleisch (*M. Schultze's Arch. f. mik. Anat.*, vol. viii. p. 453), and others. It seems likely, as Hill suggests, that since the discovery of these fine cortical plexuses our whole notions of what are known as *nerve centres*, and of the communication that exists between nerve cells and fibres, will shortly be revolutionised. The plexuses to which I refer can be seen only when certain methods of staining are employed. Exner, who is generally regarded as having discovered the plexus in the cerebral cortex, employed perosmic acid and ammonia, but since then the reagent used for the purpose of demonstrating it has almost exclusively been Weigert's hæmatoxylene dye previously referred to.* In the cortex of the cerebellum the plexus is probably densest, but it is present in all parts of the cerebral cortex as well.

Continuity of Cortical Plexus with that in White Matter.—What I would specially wish to direct attention to at present, however, is that this plexus not only prevails in the cortical grey matter, but that it appears to intertwine itself round the nerve fibres throughout a great part of the white. The large medullated nerve fibres from the cortex run into the white matter, but almost immediately become surrounded by a dense padding or casing of this nerve network. At first it might be supposed to be simply connective tissue, and it has in bygone times been always regarded, when indistinctly seen by less favourable means of demonstration, simply as the branching neuroglia. The plexus I refer to, however, as pervading the white matter of the brain is a true nerve structure, and that which is found in the cortex of the cerebrum and cerebellum is an extension or outcrop of this. The appearance presented by it a short way within the cortical grey matter, of the motor region, towards the vertex is shown in Pl. XV. fig. 3. The large medullated trunks (*a.*, *a.*) are seen coming down from the grey cortex, but shortly after penetrating into the white matter of the centrum ovale they become encased, as it were, in a dense and complex mass of medullated fibres (*d.*). Between its fibres is the granular neuroglia (*c.*), which seems to fill all the meshes formed by it.

The Plexiform Nucleus.—A similar medullated plexus also exists in certain of the ganglia, such as the thalamus and lenticular nucleus. In the former it is in a high state of development, but there is one part of the brain in which it reaches even a higher grade of complexity. I refer to a little comma-shaped body (fig. 2, *p.n.*) which lies in the angle constituted by the under aspect of the tectorial part of the corpus callosum and the upper surface of the caudate nucleus. This body, whose presence I do not remember having seen referred to, is one mass of a dense and complicated nerve plexus, and, so far as I am able to discover, is without nerve cells. It is contiguous to the caudate nucleus below, but the tissue of the one is separated from that of the other by a sharp line of demarcation. It passes for a short way underneath the corpus callosum, and at its lower extremity posteriorly, seems to be united with the tænia semicircularis. Its fibres are directly continuous with the fibres of the plexus in the white matter just referred to. It is most developed anteriorly in the region of the head of the caudate nucleus.

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* Since this paper was read various modifications of Exner's method have been introduced by Pal of Vienna and others.

In Pl. XIV. fig. 4 I have given a drawing of the plexus constituting this body as it appears when magnified about 350 diameters. The part from which the drawing was taken was immediately adjacent to the inner capsule at the point *x.* in fig. 2. The plexiform nucleus (*p.n., p.n., p.n.,*) is seen to the right; a few of the fibres of the inner capsule (*i.c.*) to the left. It will be noticed that the main bulk of the body is made up of an intertwining felt-work of nerve fibres. They stain deeply with Weigert's copper-hæmatoxylene dye, and between them, as in other regions of the brain, a quantity of granular neuroglia is interposed. It is only lately that I have made out the true nature of this body, and on account of its structure I propose to name it the *plexiform nucleus.*

Points of Origin of the Callosal Fibres.—The most of the callosal fibres which come down from the *vertex* appear to run *directly* into the corpus callosum. Their usual appearance and direction are represented in fig. 2 (*v.c.f., v.c.f.*). In passing downwards they interlace with those leaving the corpus callosum, and which are turning downwards to the two capsules.

Those, however, which are derived from the lower third or half of the cortex between the Sylvian fossa and the great longitudinal fissure (fig. 2, *p.n.f., p.n.f.*) do not appear to run directly into the corpus callosum, but pass first of all into the *plexiform nucleus* just described. Shortly after issuing from the grey matter they become united into loose bundles which penetrate through the fibres of the crossed callosal tract, and which seem to lose themselves within the *plexiform nucleus* by breaking up into its reticular network. From this reticular network fresh fibres appear to arise, and to enter the corpus callosum. In all probability, these turn downwards on the opposite side into the two capsules as fibres of the crossed callosal tract. This *plexiform nucleus* would thus possibly represent a meeting-point for many of the callosal fibres before they proceed to cross, the individual fibres losing their identity within it by splitting into an anastomising common network, from which again fresh fibres appear to arise and travel across the corpus callosum to the opposite side.

The fibres which enter this body are chiefly derived from the motor centres which in Man have been found to preside over the muscles of the tongue and face, that is to say, the lower parts of the ascending frontal and parietal convolutions, and it is conceivable that the function of the plexus contained in it is to correlate and associate their action.

Destinations of the Callosal Fibres.—After passing into the inner and outer capsules, the arched callosal fibres just described become united into dense bundles. A very large proportion of them lose themselves in the *thalamus opticus*. The excessively fibrous appearance which the thalamus presents is due to these fibres passing into it. They probably break up into a network, in the meshes of which the nerve cells are intercalated.

Are these nerve cells directly connected with the nerve fibres entering the ganglion, or is the network referred to intermediate? It seems more likely that the union is not direct, but that a plexus intervenes between the two, and that this plexus simply surrounds the nerve cells. I am even not at all convinced that the processes of the nerve cells are in all cases directly connected with the plexus. May not nerve energy generated in cells exert its influence upon nerve fibres in ways other than by direct continuity? Is it not possible that it may be transferred to the coils of a dense plexus through the liquid and neuroglia which fill up the intervals in the tissue, and that, conversely, peripheral stimuli may thus be conveyed to a nerve cell? I think this is at least conceivable, and the idea has of late been entertained by several physiologists, both in this country and abroad.

Few, if any, callosal fibres end in the *caudate nucleus*, and, curiously, as if supporting this observation, the plexus in this ganglion seems to be very scanty. .The *lenticular nucleus* may receive through the striæ medullares a considerable number, and probably some of the fibres connected with the *red nucleus* may be also callosal. A large number appear to end in the *pons and medulla* *oblongata*, while there is a probability of certain of them even extending down to the *spinal cord.*

The Direct Fibres.—This paper, however, is concerned with the connections between the cerebral cortex and the centres lower down, and as yet I have referred to only one set, namely, those which are callosal and which cross from the opposite side. There are others, of course, which run down directly, and of these the motor fibres are among the most important. These direct motor fibres lie to the *outside* of the crossed callosal tract (fig. 2, *d.f.*), and, like it, bend somewhat outwards in circumventing the ventricle. Those derived from the *marginal gyrus* seem, at least in the sheep, to lie in very close apposition with the fibres of the crossed callosal tract. In Man I calculate that about one-third of the fibres entering the anterior two-thirds of the posterior limb of the inner capsule are direct, while the remainder are crossed callosal.

From experiments made upon the cortex, it is evident that these direct fibres are derived from a wide area, one, indeed, so wide that it comes to be a question how it is that they are so few in number when they decussate in the medulla and become connected directly, or through the intermediation of the spinal cord, with the peripheral nerves. The notion at present held by most physiologists is that from the motor cells of the cortex fibres issue which are continuously prolonged downwards to the spinal cord. But if we consider the matter for a moment, it is evident that they must have been much reduced in bulk by the time they have reached the medulla, and that the pyramidal fibres of the medulla or cord cannot represent the whole of the motor fibres derived from the motor area. How, then, is this sudden falling off to be accounted for? My present conviction is that the direct continuity of the process of a ganglion motor cell in the cortex with the pyramidal tracts of the spinal cord is a myth. I am strongly inclined to believe that, just as in the case of many of the callosal fibres, the motor fibres break up into a plexus, from which again fresh fibres, those which enter the pyramidal tracts, take their origin. When the pyramidal tracts in the cord are affected by secondary degeneration, they are mapped out with the utmost precision, and the degeneration never overlaps them. Can the same be said of the degeneration further up in the centrum ovale? I do not think that it can. There is always more or less diffusion of the tract immediately and for some distance below the point of lesion, if that be cortical, and the explanation I think is to be found in the interposition of this plexus. The plexus is a means of reduction and association, a means by which the action of the many fibres coming from a particular cortical area may be combined and correlated in the few.

But the direct fibres entering the inner capsule are not all motor in their function. There are many other bands which enter it and whose function varies. Thus there is a large contingent of fibres which passes into its posterior limb from the parieto-occipital region, and whose function, there cannot be much doubt, is sensory. It has been shown, over and over again, that when it is destroyed hemianæsthesia results. Then there is a large band of fibres which comes from the prefrontal region, and which enters the anterior limb on its way back to the anterior nucleus of the thalamus, to which it becomes attached. The geniculate bodies and the pulvinar finally are connected by direct bands with the occipital region.

Plexus most abundant in Man.—One of the main differences which exist between the brain of Man and that of the lower mammalian types consists in the disproportional size of the white and grey matters. In Man the white matter is relatively more abundant than in the brain of any other mammal I have examined, and the lower we go in the scale the greater the disproportion appears to be.

Now, the cause of this seems mainly to reside in the fact that this intertwining plexus which ramifies through the whole centrum ovale is vastly more abundant in Man than in the lower animals, and hence, probably, the superiority of the human brain as an instrument of association may be accounted for.

Connections of Thalamus Opticus.—I have said that a large number of callosal fibres pass into the thalamus opticus. They lose themselves in it, apparently by becoming connected with a dense plexus. In conclusion, let me ask the question whether there are any fibres which leave the thalamus, and, if so, where they go to? Do fibres descend from the thalamus into the cerebral peduncle, ultimately to enter the spinal cord? I am becoming daily more and more convinced that, if such do exist, they must be small in number. Certain bands of fibres which are not callosal, no doubt enter the thalamus, but these seem to connect it with parts of the *cortex* which experiment has shown are associated with definite and well-located functions. Thus there are the three so-called *peduncles* of the thalamus, uniting it respectively with the prefrontal region, with the nucleus amygdalaris in the temporo-sphenoidal lobe, and with the hippocampus major. But these differ entirely in their nature from the fibres which are supposed to leave the thalamus and to pass downwards with the other descending cerebral tracts, and it seems to me that the latter, if they do exist, must be in small quantity.

How, then, is the thalamus connected peripherally, and what is its use? As yet any statement on this subject must necessarily be largely conjectural, but, all things considered, there is reason for at least supposing that this ganglion is largely concerned with the *education* of the brain *through the optic nerves and corpus callosum.* Of all the nerves in the body the optics are those by which the brain is mainly educated. They are in constant use, imperceptibly opening up the cortical grey matter to impressions made upon the periphery by light vibrations. What is the connecting link between the peripheral retina and the central cortex? The visual centre is said to be located in the occipital lobe, but the optic must subserve a far wider function in educating other parts of the cortex as well as this small area? How is it that the motor centres, for instance, are educated to a particular complicated act, purely through the sense of sight? What is the mechanism by which a sudden visual impression, accompanied by a sense of danger, will serve to throw the body instantaneously into a complicated attitude of defence? This introduces far too wide a subject of discussion to take up at present; but it seems to me likely that the callosal fibres entering the thalamus constitute the substratum by which these acts are accomplished; that they are, in fact, the means by which the opposite side of the brain is educated through vision.

Where the corpus callosum has been destroyed in infancy, imbecility seems to have been the invariable result. There are certain records of congenital deficiencies of this body which have been unaccompanied by any symptoms of note, more especially one described by Eichler (*Arch. f. Psychiat.*, vol. viii. p. 355). It seems, however, that in these cases we have to do not with a deficiency in the actual callosal fibres, but with a malformation by which they have failed to decussate in the middle line, just as so frequently happens in the anterior pyramids.

On the supposition that the thalamus subserves the purpose of concentrating the fibres which educate the higher centres through the optic, it can readily be understood how, if it were destroyed in adult life, no very evident symptoms might follow. It has already to a great extent subserved its purpose. The higher centres have been educated, and are capable of discharging their functions apart from the channels through which that education has been imparted. It has played its part, so to speak, in infancy and youth, and may now in a manner be considered as functionally inert. The impressions made upon the cerebral cortex through it are quite possibly recalled by a perfectly different set of channels; for I do not see why in the internal economy of the brain there may not be paths for *educating* the higher centres through vision, hearing, touch, and so on, and a whole set of other paths by which the results of this education may be brought into action. If such be the case—and I advance this with all due caution—the callosal system of fibres might be regarded as the great *educating system;* while the direct bundles to which I have adverted would constitute the means of adapting this education to a utilitarian purpose.

In the case of those born blind, the education of the cortex would of course be carried on through other channels, namely, through those of the remaining special senses. The nuclei of the nerves connected with these are situated in great part in the pons, medulla oblongata, and spinal cord, and these again, as already mentioned, appear to be extensively united to crossed callosal fibres which have descended in the inner capsule. By the agency of these callosal fibres they are placed in communication with the cerebral cortex on the opposite side of the body. The same mechanism for educating the cortex in fact prevails here as in the case of the optic; that is to say, there is, firstly, the peripheral nerve to receive the impression; secondly, an intermediate nucleus to which the nerve is bound; and, thirdly, a system of fibres (callosal) by means of which this nucleus is placed in continuity with the opposite cerebral cortex.

The arrangement seems a probable one; all the most important motor and sensory channels seem to cross the middle line at some point. We see this exemplified in its most simple form in the ordinary ascending and descending paths in the spinal cord; and there seems good reason for believing that the same type of construction prevails higher up. The callosal fibres would thus represent the decussation of the multiform tracts which do not cross in any of the commissures or decussations lower down. The greater number of them are probably not motor nor purely sensory in their function, but in great part *educational.* They are, in fact, the means of impressing the opposite cortical centres with the stimuli that have been made upon the intermediate centres lower down.

EXPLANATION OF PLATES XIV., XV.

Fig. 1. Perpendicular opaque transverse section through the region of the infundibulum of human brain hardened by injecting Müller's fluid. Natural size. In the centre is the corpus callosum, and at each side of it, turning upwards, outwards, and downwards in the centrum ovale to the two capsules, is the arched mass of fibres which I have named the *crossed callosal tract.* The fibres *coming in* to the corpus callosum from the cortex of the vertex and elsewhere are seen interlacing with the fibres of this arched mass. The drawing was made with the greatest care, and may be taken as being as nearly as possible a *facsimile* of the preparation from which it was copied. The brain, after being thoroughly hardened, was simply cut into segments about half an inch thick, whose surfaces were polished in the freezing microtome. Nothing further was done to it. The drawing represents the surface of one of these segments.

Fig. 2. Perpendicular oblique antero-posterior section of human brain through the corpus callosum and *crossed callosal tract.* × 10–20 diams. Stained by the author's modification of Weigert's copper-hæmatoxylene process. *c.c.*, corpus callosum; *c.c.t.*, crossed callosal tract; *v.c.f.*, *v.c.f.*, callosal fibres from the vertex; *p.n.f.*, *p.n.f.*, same, from cortex lower down, running towards the plexiform nucleus (*p.n.*); *d.f.*, direct cortical fibres lying outside the crossed callosal tract, and running down to the inner capsule (*i.c.*); *s.c.f.*, severed callosal fibres of the crossed callosal tract; *c.n.*, caudate nucleus; *x.*, part of preparation from which figure 3 was drawn.

Fig. 3. Portion of white matter immediately under the grey mantle of the cortex at the vertex in the motor region. Stained as in figure 2. × 300 diams. *a.*, *a.*, bundles of large medullated fibres passing downwards from the grey matter; *b.*, a clot in a blood-vessel; *c.*, the granular neuroglia; *d.*, the felt-like plexus of nerve fibres surrounding the straight bundles coming from the cortex.

Fig. 4. Part of plexiform nucleus and adjacent inner capsule, taken from the preparation depicted in figure 2 at point *x*. ×350 diams. *p.n.*, *p.n.*, *p.n.*, outer border of plexiform nucleus; *i.c.f.*, *i.c.f.*, descending fibres of inner capsule; *u.c.f.*, *u.c.f.*, cortical fibres derived from the grey matter shortly above the Sylvian fossa, and which apparently end in the nerve network of the plexiform nucleus.

Fig. 4.

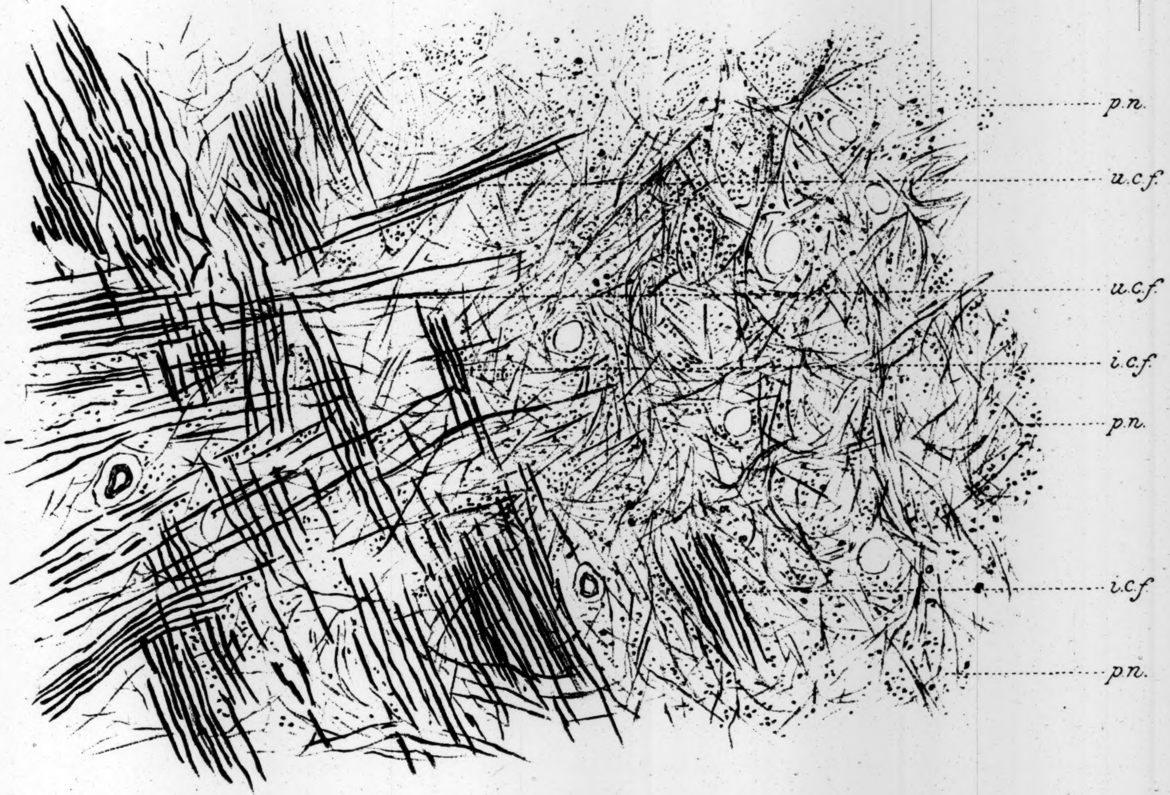

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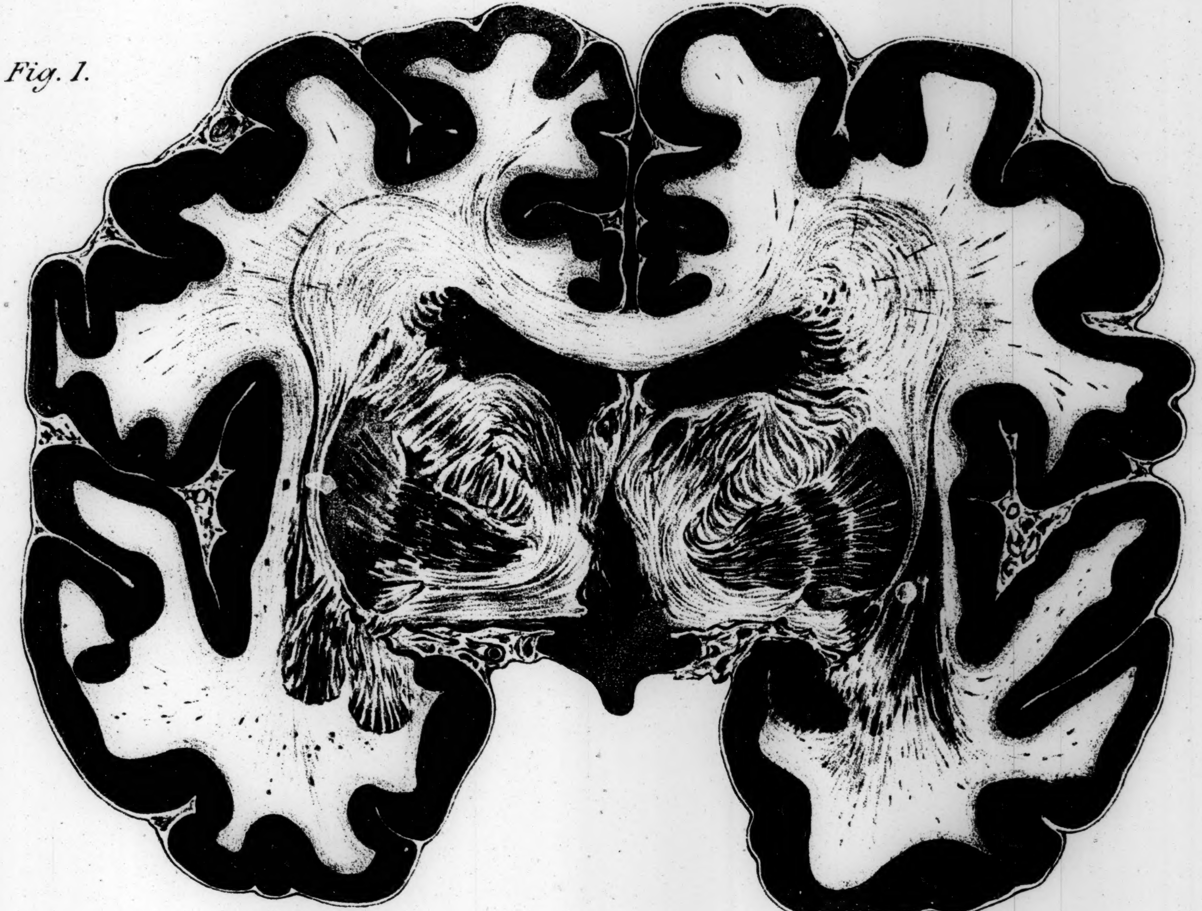
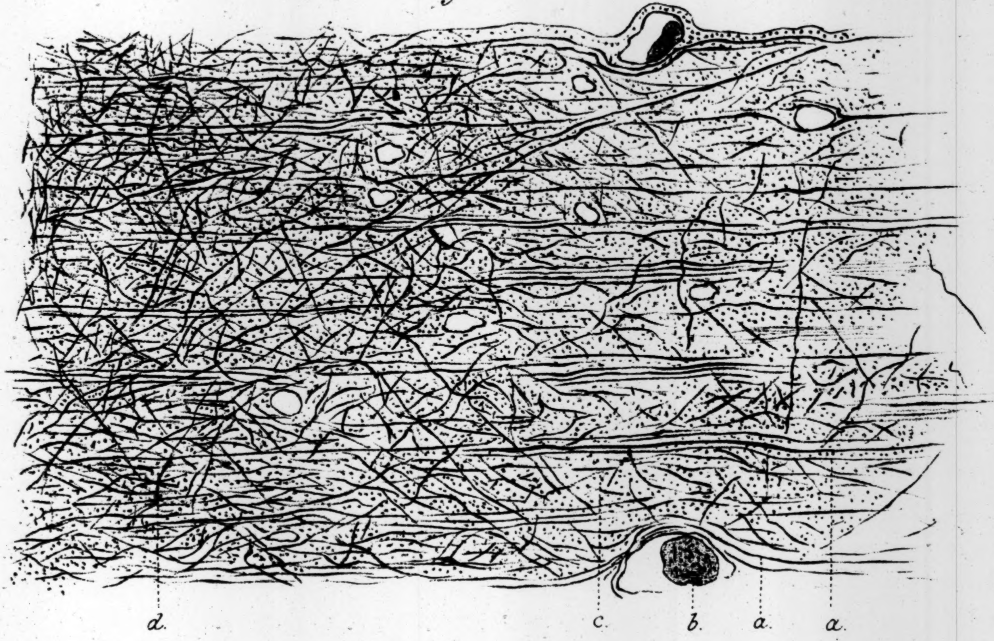
Fig. I.



F. Huth, Lith.r Edin.r

Fig. 3.



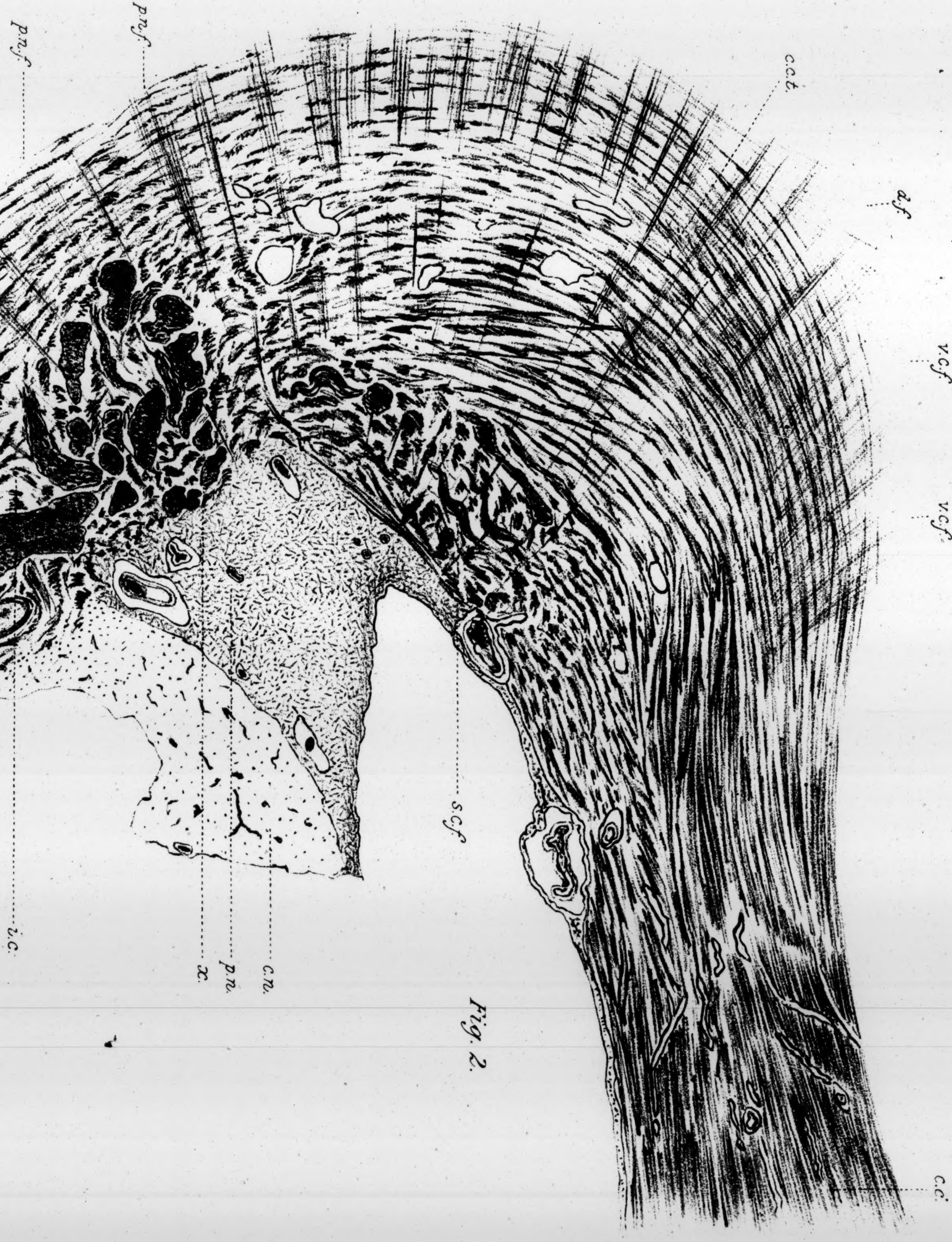


Fig. 2.

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Donations to the Library of the Royal Society from 1885 to 1887.

I. TRANSACTIONS AND PROCEEDINGS FROM LEARNED SOCIETIES, ACADEMIES, &c.

Adelaide.—Transactions and Proceedings of the Adelaide Philosophical Society. Vol. IX. 1885-86. 8vo.

University Calendar for 1886.

American Association for the Advancement of Science.—33rd Meeting (Philadelphia), 1885; also—

12th Meeting (Baltimore), 1863;
16th Meeting (Burlington), 1867;
20th Meeting (Indianopolis), 1871;
22nd Meeting (Portland), 1873;
23rd Meeting (Hartford), 1875.

Amsterdam.—Verhandelingen der Kon. Akademie van Wetenschappen. Afd. Natuurkunde, Dl. XXV., 1887. Afd. Letterkunde, Dl. XVI., 1886. Verslagen en Mededeelingen, Natuurkunde, 3e Rks., Dl. II., 1886. Letterkunde, 3e Rks., Dl. III., 1887. Processen Verbaal, 1881-83. Jaarboeck, 1885. Poemata Latina. Catalogus der Boekerij der Akad.

Kon. Zoologisch Genootschap "Natura Artis Magistra." Bijdragen, 13e Aflev., 1885-86.

Wiskundig Genootschap, Dl. II., 1884-86. Nieuw Archief voor Wiskunde XIII., 1, 2, 1886; XIV., 1, 1887. Opgaven III., 1, 2, 3, 1887.

Flora Batava: Afbeelding en Beschrijving van Nederlandsche Gewassen. Voortgezet door F. W. Van Eedden. 274-280 Afleveringen, 1882-84, 1884-86. (*From the King of Holland.*)

Australasia.—Proceedings and Transactions of the Queensland Branch of the Geographical Society of Australasia. Vol. II. Pt. 1. 1886-87.

Baltimore.—Johns Hopkins University.—The American Journal of Mathematics. Professor Newcomb (Editor). Vols. VI.-IX. 1884, 1885, 1886.

The American Chemical Journal. Edited by Professor Remsen. Vol. IX. 1887.

The American Journal of Philology. Edited by Professor Gildersleeve. Vol. VIII. 1887. 8vo.

Studies from the Biological Laboratory of the Johns Hopkins University. Vol. IV. 1, 2. 1887. 8vo.

University Studies in Historical and Political Science. 5th Ser. Vols. I.-XII. 1887.

University Circulars.

Basel.—Verhandlungen der Naturforschenden Gesellschaft. Bd. VI. 1884. 8vo. Bd. VIII. 2. 1887. 8vo.

Batavia.—Catalogus der Numatische Verzameling (1886) en der Archeologishe Verzameling (1887).

Regenwaarnemingen in Nederlandsch Indie. 1885–86. 8vo.

The Batavian Society of Arts and Sciences.—Verhandelingen van het Bataviaasch Genootschap van Kunsten en Wetenschappen. Deel XLVI. 1886–87. 8vo.

Tijdschrift voor Indische Taal-Land-en Volkenkunde. Deel XXXI. Nos. 4, 5, 6. 1884–85. 8vo.

Natuurkundig Tijdschrift voor Nederlandsch Indie uitgeven door de Kon. Natuurkundig Vereeniging. 1884–85. 8vo.

Notulen, Deel XXIV., XXV. 1885–87.

Belfast.—Proceedings of the Natural History and Philosophical Society for 1886–87.

Bergen.—Museums Aarsberetning for 1886. 8vo.

Berlin.—Abhandlungen der Königlichen Akademie der Wissenschaften, 1886.—Sitzungsberichte, 1886–87. 8vo.

Fortschritte der Physik im Jahre 1881. Dargestellt von der physikalischen Gesellschaft zu Berlin. 1te Abtheil.—Allgemeine Physik, Akustik. 2te Abtheil.—Optik, Wärmelehre, Elektricitätslehre. 3e Abtheil.—Physik der Erde. 8vo. Berlin.

Verhandlungen der Physikalischen Gesellschaft im Jahre 1886.

Zeitschrift der Deutschen Meteorologischen Gesellschaft. Nos. 9–12. 1886–87. 8vo.

Meteorologische Zeitschrift redigirt von Dr J. Hann (Wien) und Dr W. Köppen (Hamburg), 1887.

Ergebnisse der Meteorologischen Beobachtungen im Jahre 1886, herausgegeben von dem Preussischen Meteorologischen Institut. 4to.

Königliche Technische Hochschule : Rede, 1886. 4to.

Bern.—Beiträge zur geologischen Karte der Schweiz, XXe Lief. Description Géologique des Préalpes du Canton de Vaud et du Chablais. Texte et Atlas, 1887 ; XXIVe Lief., Beilage, Kreide und Tertiar Versteinerungen, 1887 ; Feuilles V.–XVIII., XXI.–XXV. Berne. 4to. (*From the Commission Fédérale Géologique.*)

Mittheilungen der Naturforschenden Gesellschaft in Bern. Nos. 1133–1168. 1886–87. 8vo.

Berwickshire.—Berwickshire Naturalists' Club, Proceedings of. Vol. XI. 1, 2, 3. 1885–86. 8vo.

Birmingham.—Proceedings of the Birmingham Philosophical Society, Vol. V. Pt. 2. 1886–87. 8vo.

Bombay.—Journal of the Bombay Branch of the Royal Asiatic Society. Vol. XVIII. Prof. Peterson's Report on Sanskrit MSS. in the Bombay Circle. 1884–86.

Magnetical and Meteorological Observations made at the Government Observatory for 1885. Bombay. 4to.

Bonn.—Verhandlungen des Naturhistorischen Vereines der Preussischen Rheinlande und Westfalens. 1887. 8vo.

Bordeaux.—Mémoires de la Société des Sciences Physiques et Naturelles. 3e Sér. Tom. III. 1886.

Observations Pluviométriques et Thermométriques dans la Gironde. 1885–86.

Bulletins de la Société de Géographie Commerciale. 1886. 8vo.

Boston.—Memoirs of the Boston Society of Natural History. Vol. III. No 13. 1886. 4to.

Proceedings of the Boston Society of Natural History. Vol. XXIII. 1886. 8vo.

Proceedings of the American Academy of Arts and Sciences. Vol. XXII. 1887.

Brera.—See *Milan.*

British Association for the Advancement of Science.—Reports of the Meetings at Birmingham and Manchester. 1886–87.

Brunswick.—Jahresbericht des Vereins für Naturwissenschaft. 1881–86.

Brussels.—Bulletin de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tome LVI. 1887. 8vo.

Mémoires de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tome XLVI. 1886. 4to.

Mémoires Couronnés et Autres Mémoires publiés par l'Académie Royale des Sciences, &c., de Belgique. Tomes XXXVII.–XXXIX. 1884.

Mémoires Couronnés et Mémoires des Savants Étrangers publiés par l'Académie Royale des Sciences, &c., de Belgique. Tomes XLVII., XLVIII. 1886. 4to.

Biographie Nationale. Tome IX. 1, 2, 3. 1885–87.

Annuaire de l'Académie Royale. Année, 1888. 8vo.

Annuaire de l'Observatoire Royal. Années, 1887–88. 8vo.

Annales de la Société Scientifique de Bruxelles. Années, 1885–86. 8vo.

Bucharest.—Academia Romana. Extrasu din Analele, Memorii si Notite. 1886–87. Also Documents relating to the History of Roumania, and Translations of the Latin Classical Authors into Roumanian—a Roumanian and Latin Dictionary. Fasc. I.–IV., Miron Costin, opere complete, &c. Tomul III. 1886–88.

Analele Institutului Meteorologic al Romaniei. Tom. I. 1885. (In French and Roumanian.)

Buda-Pesth.—Königl. Ungarische Naturwissenschaftliche Gesellschaft, Berichte, Bd. III. 1885. 8vo.

Ertekezesek. kotet VII.–XV., 1881–86, Bulletins, 4–5, 1885–86, and other publications of the Magyar Academy.

Mathematische und naturwissenschaftliche Berichte aus Ungarn. Bd. IV. 1885–86.

Ungarische Revue, 1887.

Buenos-Aires.—Description physique de la République Argentine, par le

Dr H. Burmeister. Ostéologie der Gravigraden. 1e Abtheil. Avec Atlas. 1886. Fol.

Calcutta—Asiatic Society of Bengal.—Proceedings of the Asiatic Society of Bengal for 1886-87. 8vo.

Journal of the Asiatic Society of Bengal for 1886-87. 8vo. See *Indian Government.*

Catalogue of the Moths of India, by E. C. Cotes and Col. C. Swinhoe. Pt. 1. 1887. 8vo.

California.—Bulletins of the California Academy of Sciences. 1887. State Mining Bureau: Annual Reports, 1885.

Cambridge.—Transactions of the Philosophical Society. Vol. XIV. Pt. 2. 1887. 4to.—Proceedings, 1887. 8vo.

Cambridge (U.S.)—Harvard College.—Annual Reports of the Curator of the Museum of Comparative Zoology at Harvard College. 1886-87.

Bulletin of the Museum of Comparative Zoology at Harvard College. Vol. XIII. 1887. 8vo.

Memoirs of the Museum of Comparative Zoology at Harvard College. Vol XV.—Report on the Annelids, by E. Ehlers. 1887. 4to. Vol. XVI.—On *Taxodium distychium.* By N. S. Shaler. 1887.

Annals of the Astronomical Observatory at Harvard College. Vol. XVII. The Almacantar, by S. C. Chandler, jun. 4to. 1887. Vol. XVIII. 1887.

Meteorological Observations, 1887.

Memoirs of the American Academy of Arts and Sciences. Centennial Volume. Vol. XI. 1886.—Proceedings. 1884-86.

Canada.—The Royal Society of Canada. Vol. IV. 1886.

Geological Survey of Canada. Reports of Progress, 1885. 8vo. (*From the Government of the Dominion.*)

Descriptive Catalogue of Canadian Plants. Pt. 3. 1886. Apetalia, by J. Macoun.

Canadian Society of Civil Engineers. Vol. I. 1887.

Catania.—Atti dell' Accademia Gioenia di Scienze Naturali. Ser. 3za. Tom. XIX. 1887. 4to.

Ceylon Government.—The Lepidoptera of Ceylon. Parts XII. and XIII. By F. Moore, F.Z.S. 1886-87. 4to.

Chemnitz.—Bericht der Naturwissenschaftlichen Gesellschaft, 1884-86.

Cherbourg.—Mémoires de la Société Nationale des Sciences Naturelles et Mathématiques. Tome XXV. 1887. 8vo.

Chicago.—Annual Reports of the Board of Directors of the Chicago Astronomical Society and of the Dearborn Observatory. 1885-1886. 8vo.

Christiania.—Den Norske Nordhavs-Expedition. 1883-86.

Zoologi. Nordhav's Dybder, Temperatur, og Strömninger, ved H. Mohn. 1887. (*From the Norwegian Government.*)

Norske Gradmalings Kommission. Das mittlere Dreiecknetz, 1887.

Christiania.—Nyt Magazin., Bd. 30. 1886. 8vo.

Archiv for Mathematik og Naturvidenskab, Bd. X. 1-4. 1886. 8vo.

Beobachtungsergebnisse der Norwegischen Polar Station Bossekop in Alten. Theil 1. 1887. 4to.

Cincinnati.—The Journal of the Cincinnati Society of Natural History. Vol. X. 1887.

University of Cincinnati.—Publications of the Observatory. Zone Catalogue of 4050 Stars. 1887.

Connecticut.—Transactions of the Connecticut Academy of Arts and Sciences. Vol. VII. Pt. 1. 1886. 8vo.

Copenhagen.—Mémoires de l'Académie Royale de Copenhague. Classe des Sciences. 6e Série. Vol. IV. 3, 4, 5. 1886.

Översigt over det Kongelige Danske Videnskabernes Selkabs Forhandlinger. 1886-87. 8vo.

Cordoba (*Republica Argentina*).—Boletin de la Academia Nacional de Ciencias de la Republica Argentina. Tom. IX., X. 1886-1887.

Informe oficial de la Comision scientifica de la Expedicion al Rio Negro. Tom. V. Entrega 3. 1887. Folio.

Resultados del Observatorio Nacional Argentino. Tomo VI. ; Observaciones del ãno 1875. 4vo.

Catalogo General.—Tomo IX. Posiciones medias de Estrellas Australes determinadas en el Observatorio Nacional, en el ãno 1876.

Cornwall.—Transactions of the Royal Geological Society of Cornwall. Vol. XI. Pt. 1. 1887.

Dantzig.—Schriften der Naturforschenden Gesellschaft. Bd. VI. 1887.

Die Praehistorischen Denkmäler der Provinz Westpreussen und der angrenzenden Gebiete. Von Dr Lissauer. 1887.

Davenport.—Proceedings of Academy of Natural Sciences. Vol. IV. 1886.

Delft.—Annales de l'École Polytechnique. Tome III. 1887. 4to.

Dijon.—Mémoires de l'Académie des Sciences, Arts et Belles-Lettres. 3e Série. Tome IX. 1885-86.

Dorpat.—Inaugural Dissertations, 1887.

Meteorologische Beobachtungen. 1887. 8vo.

Zwanzigjährige Mittelwerthe aus den Meteorologischen Beobachtungen. 1866 bis 1885, für Dorpat. Von Dr Weihrauch. 1887. 8vo.

Dublin.—Royal Irish Academy Proceedings (Science). Series II. Vol. IV. 1885-86. (Polite Literature and Antiquities.) Series II. II. Nos. 5, 6, 7. 1885-6.

Todd Lectures. Vol. II. Pt. 1 ; Irish Lexicography, 1885.

Transactions of the Royal Irish Academy (Science). Vol. XXIX. Nos. 1, 2 ; Plane Sections of Cylindroid—Ogam Monument. 1887. 4to. (Polite Literature and Antiquities.) Vol. XXVII. 7, 8. 1886.

Dublin.—Cunningham Memoirs. Nos. IV. Dynamics and Modern Geometry. By Sir Robert S. Ball. 1886. 4to.

The Scientific Proceedings of the Royal Dublin Society. (New Series.) Vols. IV., V. 1887.

The Scientific Transactions of the Royal Dublin Society. Vol. III.

Journal of the Royal Geological Society of Ireland. Vol. VIII. 1887. (*From the Society.*)

Dunecht Observatory.—Determinations of Longitude and Latitude, 1885.

Dunsink (*Dublin*).—Astronomical Observations and Researches made at Dunsink. 6th Part. 1887. (*From the Observatory.*)

Edinburgh.—Transactions of the Royal Scottish Society of Arts. Vol. XI. 1885–87. 8vo.

Annual Reports of the Council of the Royal Scottish Academy of Painting, Sculpture, and Architecture. 1887. 8vo.

Edinburgh Astronomical Observations. Vol. XV. 1878–86. Star Catalogue, Discussion and Ephemeris for 1830 to 1890, 4^h–24^h, R.A.

Highland and Agricultural Society of Scotland's Transactions. 4th Series. Vol. XIX. 1887. 8vo.

Transactions and Proceedings of the Botanical Society. Vol. XVII. 1886, 1887. 8vo.

Scottish Geographical Society. Vol. III. 1887. 8vo.

Transactions of the Edinburgh Geological Society. Vol. V. Part 3. 1887. 8vo.

Proceedings of the Edinburgh Mathematical Society. 2nd Sess. 1883–84. 8vo.

Journal of the Scottish Meteorological Society for 1886. 8vo.

Proceedings of the Royal Physical Society. Session 1886. 8vo.

Monthly and Quarterly Returns of the Births, Deaths, and Marriages registered in Scotland. 1887. (*From the Registrar-General.*)

Edinburgh University Calendar for Sessions 1887–88. 8vo.

Ekatherinebourg.—Bulletin de la Société Ouralienne d'Amateurs des Sciences Naturelles. Tome X. 2. 1887.

Erlangen University.—Inaugural Dissertations. 1887.

Physicalisch-Medicalische Societät. 1886.

Essex Field Club.—The Journal of (The Essex Naturalist). 1887. 8vo.

Essex Institute (*U.S.*).—See *Salem.*

Frankfurt-a-M.—Abhandlungen herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. Bd. XV. 1. 1887. 4to.

Berichte über die Senckenbergische Naturforschende Gesellschaft. Bd. für 1887. 8vo.

Algerien u. Tuniz, von Dr W. Kohelt. 1885.

Geneva.—Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome XXIX. Pt. 1. 1885.

Genoa.—Annali del Museo Civico di Storia Naturale. (Il Marchese G. Doria, Direttore.) Vol. III. Elenco degli Uccelli Italiani. Vols. IV., V. 1886–87.

Glasgow.—Proceedings of the Philosophical Society of Glasgow. Vol. XVIII. 1887.

Transactions of the Geological Society of Glasgow. Vol. VIII. 1886. 8vo.

Göttingen.—Abhandlungen der Konigl. Gesellschaft der Wissenschaften. Bd. XXXII. 1886.

Nachrichten von der K. Gesellschaft der Wissenschaften und der Georg-Augustus-Universtät, aus den Jahren 1886–87. 8vo.

Gelehrte Anzeigen, 1886–87.

Graz.—Mittheilungen des Naturwissenschaftlichen Vereines für Steiermark. Jahrg. 1886. 8vo.

Greenwich Royal Observatory.—Spectroscopic and Photographic Results. 1885. 4to.

Astronomical, Magnetical, and Meteorological Observations, 1885. 4to.

Numerical Lunar Theory. By Sir George Airy. 4to. 1885.

Haarlem.—Archives Néerlandaises des Sciences Exactes et Naturelles, publiées par la Société Hollandaise de Harlem. Tomes XX.–XXI. 1885–87. 8vo.

Nieuwe Naamlijst van Nederlandsche Schildvleugelige Insectens (Insecta Coleoptera). 1887. 4to.

Archives du Musée Teyler. Serie II. Vol. III. 1. 1887.

Teyler's Godgeleerd Genootschap. N. Serie, elfde Deel. 1885.

Halifax.—Proceedings of the Yorkshire Geological and Polytechnic Society. Vol. VIII. 1884. 8vo.

Halifax (*N.S.*)—Proceedings and Transactions of the Nova Scotian Institute of Natural Science. Vol. VII. 1887. 8vo.

Halle.—Nova Acta Academiæ Caesareae Leopodino-Carolinae Germanicae Naturae Curiosorum. Tom. XLIX.–LI. 1887. 4to.

Leopoldina, amtliches Organ der K. Leopold-Carolinisch-Deutschen Akademie der Naturforscher. Hft. XXII.–XXIII. 1886–87. 4to.

Abhandlungen der Naturforschenden Gesellschaft. Bd. XVI. 1886. 4to.

Mittheilungen des Vereines für Erdkunde, 1887. 8vo.

Hamburg.—Abhandlungen aus dem Gebiete der Naturwissenschaften vom Naturwissenschaftlichen Verein. Bd. X. 1887.

Helsingfors.—Acta Societatis Scientiarum Fennicae. Tom. XIV. 1883.

Notiser ur Sallskapets pro Fauna et Flora Fennica Forhandlingar. Ny Serie. Hälft. 5. 1885.—Meddelanden, 1886.

Öfversigt af Finska Vetenskaps-Societens Förhandlingar. 1883–1886. 8vo.

Expédition Polaire Findlandaise. Tome 1. Météorologie, 4to. 1886. Magnétisme terrestre. Stations, Sodankylä et Kultala.

Bidrag til Kännedom af Finlands Natur och Folk, utgifna af Finska Vetenskaps-Societeten. Häft. 44. 1887. 8vo.

Hongkong Observatory.—Magnetic and Meteorological Observations during 1886. Fol.

Indian Government, Calcutta.—Records of the Geological Survey of India. Vol. XX. 1887.

Palæontologia Indica. Series X. Vol. III. 4.—The Labyrinthodent. Pts. 7, 8.—Crocodilia, Lacertilia, and Ophidia. 1886. Vol. IV. 1.—Mammalia, supplement. 1886. Series XII. Vol. IV. Fossil Flora of Bengal Coalfields, 1886, 1887. Series XIII. Productus Limestone Fossils, 1886. Series XIV. 5, 6. Bryozoa, Annelida, Echinodermata, Cœlenterata. 1886.

Catalogues of the Siwalik Pleistocene and Prehistoric Vertebrata in the Indian Museum.

The Flora of British India. By Sir J. D. Hooker, M.D. Part XIII. 1886.

Operations of the Great Trigonometrical Survey. Vol. IVA. 1886. 4to.

Japan.—Transactions of the Seismological Society. Vols. X., XI. 1887.

Memoirs of the Science Department of the University of Tokio. 1886–87.

Memoirs of the Literature College of the Imperial University. The Language, Mythology, &c., of Japan, viewed in the light of Arts Studies. 1887. 8vo.

Mittheilungen aus der Medicinischen Facultät der Kaiserlich Japanischen Universität, 1887. 8vo.

Mittheilungen der deutschen Gesellschaft für Natur-und Völkerkunde Ostasiens zu Yokohama. Bd. IV. 35. 1885.

Jena.—Jenaische Zeitschrift für Naturwissenschaft, herausgeben von der Medicinish-Naturwissenschaftlichen Gesellschaft zu Jena. Bde. XX., XXI. 1887. 8vo.

Kasan.—Isvyaistiya i Ouchenui Sapiski Imperatorskago Kasanskago Universiteta. 1886. 8vo.

Kew.—Kew Observatory Report for 1886–87. 8vo.

Kiel.—Schriften der Universtät zu Kiel. Inaugural University Dissertations. 1886.

Kiev University.—Universitetskiya Isvyaistiya, 1886–87.

Königsberg.—Universitäts-Sternwarte. Beobachtungen. 37^{e} Abtheil. Theil 1, 1882; Theil 2, 1886.

Lausanne.—Bulletin de la Société Vaudoise des Sciences Naturelles. 2de Série. 1887. 8vo.

Leeds.—Philosophical and Literary Society Reports, 1886–87. 8vo.

Leipzig.—Berichte über die Verhandlungen der Königl. Sächsischen Gesellschaft der Wissenchaften. Math. Phys. Classe. 1887. 8vo.—Philologisch-Historische Classe. 1887.

Abhandlungen der Math.-Physischen Classe. Bd. XIII. 1885–86. —Phil. Hist. Classe. Bd. X. 1887. 8vo.

Preisschriften gekrönt u. herausgegeben von der Fürstlich Jablonowski'schen Gesellschaft. Flächen vierter Ordnung, 1886. 8vo.

Leyden.—University.—Inaugural Dissertations.

Nederlandsche Dierkundige Vereenigings Tijdschrift. 1888.

Lille.—Société Géologique du Nord. Annales XIII. 1885–86. 8vo.

Lisbon.—Boletin da Sociedade de Geographia. 1886–87.

Academia Real. Memorias. Tom. V., VI. 1882–86.

Cartas de Alfonso de Albuquerque, seguidas de documentos que as elucidan. Tomo I. 1884.

Jornal. N^{ros} XXX.-XLIV. 1881-87.

Conferencias :—Acerca dos Infinitamente Pequenos. 1884. Circulacão da Materia. 1886.

Historia dos Estabelecimentos. Tom. X.–XIV. 1882–85.

As Provincias Ultramarinas. Tom. I.–III. 1883–85.

Curso de Silvicultura, por A. X. P. Coutinho. Tomo I. 1886.

O Mercader de Veneza. Traduccão, por Buhão Pato. 1881. 8vo.

Liverpool.—Proceedings of the Literary and Philosophical Society. Vol. XL. 1886. 8vo.

London.—Proceedings of the Society of Antiquaries. Vol. XI. 1887.—Archæologia; or Miscellaneous Tracts relating to Antiquity. Vol. L. 1885–87. 4to.

Journal of the Anthropological Institute of Great Britain and Ireland. Vols. XVI., XVII. 1886–87. 8vo.

Journal of the Society of Arts. 1886–87. 8vo.

Journal of the Royal Asiatic Society of Great Britain and Ireland. Vol. XIX. 1887. 8vo.

Nautical Almanac and Astronomical Ephemeris for the Year 1891. (*From the Lords of the Admiralty.*)

Monthly Notices of the Royal Astronomical Society. Vols. XLVII., XLVIII. 1886–87. 8vo.—Memoirs of the Royal Astronomical Society, Vol. XLVIII. 2. 1885. 4to.

Reports of the Scientific Results of the Exploring Voyage of H.M.S. "Challenger." Vols. XX.–XXII. (Zoology.) 1887. 4to. (*From the Lords of the Treasury.*)

Journal and Abstracts of Proceedings of the Chemical Society. 1886–87. 8vo.

Transactions of the Clinical Society of London. Vol. XX. 1887.

Minutes of Proceedings of the Institution of Civil Engineers, Vols. LXXXVIII.–XC. 1886–87. 8vo.

Institution of Mechanical Engineers, Proceedings. 1887. 8vo.

Proceedings of the Royal Geographical Society. New Series. Vol. IX. 1887. 8vo.

Quarterly Journal of the Geological Society. Vol. XLIII. 1887; Abstracts, 1886–87.

Proceedings of the Geologists' Association. Vol. X. 1887.

Journal of the East Indian Association. Vol. XIX. 1887. 8vo.

Colonial and Indian Exhibition Report. 1886. 8vo.

Journal of the Linnean Society. Zoology. 1886–87.—Botany. 1886–87.

London.—The Transactions of the Linnean Society. Second Series. Botany. Vol. II. 1886–87. Zoology. Vol. IV. 1887. 4to.

Proceedings of the London Mathematical Society. 1886–87. 8vo.

Medical and Chirurgical Transactions published by the Royal Medical and Chirurgical Society. Vol. LXX. 1887. 8vo.—Proceedings of the Royal Medical and Chirurgical Society. New Series. Vol. I. 1887. 8vo.

Quarterly Journal of the Meteorological Society. 1886–87. 8vo.

Meteorological Society.—The Meteorological Record: Monthly Returns of Observations made at the Stations of the Meteorological Society. Nos. 23–27. 1886–87.

Meteorological Council.—Report of the Meteorological Council to the Royal Society. Report for Year ending 31st March 1887.

Quarterly Weather Report of the Meteorological Office. New Series. For 1878–79. 4to.

Meteorological Observations at Stations of Second Orders, for 1883. 4to.

Hourly Readings. 1884–85.

Monthly Weather Report. 1886–87.

Weekly Weather Report. 1886–87.

Atlantic Weather Charts. Part III. February–May 1883.

Journal of the Royal Microscopical Society, containing its Transactions and Proceedings. New Series. 1886–87. 8vo.

Statistical Report of the Health of the Navy for 1885. (*From the Lords Commissioners of the Admiralty.*)

The Mineralogical Magazine and Journal of the Mineralogical Society of Great Britain and Ireland. Nos. 34, 35. 1886–87. 8vo.

British Museum.—Catalogue of the Lizards. Vol. III. By G. A. Boulenger. 1887.

A Guide to the Exhibition Galleries in the Departments of Geology and Palæontology. 1886.

Guide to the Galleries of Reptiles and Fishes. 1887.

Guide to the Shell and Starfish Galleries. 1887.

Guide to the Sculptures of the Parthenon in the Department of Greek and Roman Antiquities. 1886.

Guide to the Mausoleum Room in the Department of Greek and Roman Antiquities. 1886.

Guide to the Nimrod Central Saloon. 1886.

Catalogue of English Coins. Anglo-Saxon Series. Vol. I. 1887.

Catalogue of the Greek Coins of Peloponnesus in the British Museum. 1886. 8vo.

Transactions of the Pathological Society of London. Vols. XXXVI., XXXVII. 1885-86.—Proceedings, 1885–86. 8vo.

London.—Pharmaceutical Society, Journal of, 1886, 1887.

Philosophical Transactions of the Royal Society. Vols. CLXXVI.–CLXXVIII. 1885–87.—Proceedings of the Royal Society. Vols. XLII., XLIII. 1886–87.

Proceedings of the Royal Institution of Great Britain. 1887.

Journal of the Statistical Society. Vol. L. 1887. 8vo. And Catalogue of Library, 1886.

Transactions of the Zoological Society of London. Vol. XII. 1886–87. 4to.—Proceedings for the year 1887. 8vo.

Louvain.—Annuaires de l'Université de Louvain. 1887. 12mo.

Liber Memorialis, 1887.

Lund.—Acta Universitatis Lundensis. Mathematik och Naturvetenskap. Tom. XXII., XXIII. 1885–86.—Philosophi, &c. Tom. XXII., XXIII. 1885–86.—Rätts och Staatsvetenskap. Tom. XXIII. 1885–86.

Luxemburg.—L'Institut Royal Grand-Ducal. Tome XX. 1886.

Observations Météorologiques. Moyennes de la Période 1854–1883.

Lyons.—Mémoires de l'Académie des Sciences, Belles-Lettres et Arts. Classe des Sciences, Tome XXVII. 1885.—Classe des Lettres, Tome XXIII. 1886.

Musée Guimet. Annales, Tomes X., XI., XII. 1886–1887. 8vo. —Revue de l'Histoire des Religions. Tomes XIV., XV., XVI. 1886–87.

Madras.—Journal of Literature and Science. 1886–87.

Madrid.—Memorias de la Comision Geologica de España. Provincia de Alava. 1885.

Boletin de la Commission del Mapa Geologico de España. Tomo XIII. 2. 1886.

Academia de Ciencias.—Memorias, Tom. XI., XII., XIII. 1887.—Revista de los Progresos de las Ciencias. Tomo XXII. 1887. 8vo.

Manchester.—Transactions of the Manchester Geological Society. Vol. XIX. 1886–87.

Literary and Philosophical Society. Memoirs, 3rd Series, Vol. X. 1887.—Proceedings. Vols. XXV., XXVI. 1886–87. 8vo.

Marseilles.—Bulletin de la Société Scientifique Industrielle. 1885.

Mexico.—Sociedad Scientifica "Antonio Alzate." Tomo I. 1887.

Milan.—Reale Istituto di Science e Lettere. Memorie: Classe di Lettere e Scienze Morali e Politiche. Vol. XVII. 1885.

Atti della Società Italiana di Scienze Naturali. Vol. XXVIII. 1886. 8vo.

Publicazioni del Reale Osservatorio di Brera in Milano. XXV. 4to. Osservazioni Meteorologiche Orarie—Simplificazioni nel Calcolo delle Perturbazioni dei piccoli Pianeti da A. Venturi. Stelle cadenti (1871), &c. 1886–87. 8vo.

Atti della Società Crittogamologica Italiana. Congresso nazionale Botanica Crittogamica. 1887. 8vo.

Milan.—Società d'Industriali Italiana. Vol. I. 1887. 8vo.

Modena.—Memorie della Regia Accademia di Scienze Lettere ed Arti. Ser. II. Tom. IV. 1886. 4to.

Atti della Società dei Naturalisti. Ser. III. Vol. V. 1886.

Montpellier.—Académie des Sciences et Lettres de Montpellier : Mémoires de la Section des Sciences. Tome XI. 1885–86.—Section des Lettres. Tome VIII. Fasc. 1, 2, 3, 1886–87. Tom. VI., 1, 1886.

Montreal.—Natural History Society, Proceedings of. 1887. 8vo.

Moscow.—Annales de l'Observatoire de Moscou. 2^e Ser. Vol I. 1884. 4to.

Beilage zum Bulletin de la Société Impériale des Naturalistes de Moscou. Meteorologische Beobachtungen, 1886. 8vo.

Nouveaux Mémoires de la Société Impériale des Naturalistes de Moscou. Tome XV. 1885.

Munich.—Abhandlungen der k. Bayerischen Akademie der Wissenschaften der Mathematisch-Physikalischen Classe, Bd. XV., XVI. 1886, 1887.—Philosophisch-Philologische Classe, Bd. XVI. 1885.—Historische Classe, Bd. XVII. 1885.—Sitzungsberichte der Mathematisch-Physikalischen Classe der k. B. Akademie der Wissenschaften. 1886, 1887.—Sitzungsberichte der Philosophisch-Philol. und der Historischen Classe, 1886, 1887. 8vo.

Münchene Sternwarte. Astronomische Bestimmung der Polhöhen, 1885. 4to.

Gedächtnissreden auf Leopold von Ranke und Joseph von Frauenhofer. 1887. 4to.

Naples.—Memorie della R. Accademia delle Scienze Fisiche e Matematiche. Ser. III. Tom. V. 1885.

Rendiconti della R. Accademia. 1886. 4to.

Mittheilungen aus der Zoologischen Station zu Neapel. Bde. VI., VII. 1887. 8vo.

Neuchatel.—Bulletin de la Société des Sciences Naturelles de Neuchatel. Tome XV. 1886.

New York.—Bulletin of the American Museum of Natural History. 1886. 8vo.

Natural History of York. Palæontology. Vol. V. Pt. 1—Monomyaria, by James Hall. Albany, 1879. 4to.

American Geographical Society. Vol. XIX. 1887. 8vo.

Nice.—Annales de l'Observatoire. Tom. II. 1887.

Nijmegen.—Nederlandsch Kruidkundig Archief.—Verslagen en Mededeelingen der Nederlandsche Botanische Vereeniging. 2^e Serie. 4^e Deel, 5^e Stuk. 1887.

Oberpfalz und Regensburg.—Verhandlungen des historischen Vereines. Bde. XL.–XLI. 1886–87. 8vo.

Odessa.—Zapiski Novorossiskago Obshestva Estestvoispuitatelei. Tom. XI. 1887. 8vo.

Offenbach.—Verein fur Naturkunde ; Jahresbericht, 1885–87. 8vo.

Ohio.—Mechanics Institute. Vol. II. 1883.

Oxford.—Results of Astronomical Observations at the Radcliffe Observatory. XLI.–XLII. 1884–85. 8vo.

Palermo.—Hortus Botanicus Palermitanus. 1886.

Paris.—Comptes Rendus des Séances de l'Académie des Sciences. Dec. 1886 to Dec. 1887. 4to.

Oeuvres complètes de Laplace. Tome VII. 1887. 4to.

Oeuvres complètes d'Augustin Cauchy, publiées sous la Direction de l'Académie. 2e Série, Tome VI. 1887.

Comptes Rendus de l'Académie des Inscriptions et Belles-Lettres. 1886–87. 8vo.

Bulletins de la Société d'Anthropologie. 1887. 8vo.

Annales de l'École Normale Supérieure. Tome XI. No. 4. 1882.

Annales des Mines, 1885–86.

Bulletins des Séances de la Société Nationale d'Agriculture de France. 1887. 8vo.—Memoires. Tome CXXXI. 1887.

Bulletins de la Société de Géographie. 1886, 1887.—Comptes Rendus. 1886–87.

Société Géologique de France.—Bulletins. 3e Série. Tomes X., XV. 1886–87. 8vo.—Mémoires, 3e Série. Tome IV. (3).

Formation des Couches de Houille. 1887. 4to.

Annales Hydrographiques. 1887. 8vo.

Mission Scientifique du Cap Horn. 1882–83. Tome IV. Géologie. Tome VI. Zoologie. 4to. (*From Minister of Marine.*)

Publications du Dépot de la Marine, 1886–87.

Annales de l'Observatoire de Paris. Mémoires. Tome XVIII. 1881–82.

Rapport Annuel sur l'État de l'Observatoire de Paris par M. le Contre-amiral Mouchez, pour l'Année, 1886.

Journal de École Polytechnique. 54, 55 Cahiers. 1886, 1887.

Bulletins de la Société Mathématique de France. Tome XV. 1887. 8vo.

Ministère de l'Instruction Publique. Dictionnaire de l'Ancienne Langue Française et de tous ses Dialectes du IXe au XVe Siècle. Par Frédéric Godefroy. Fasc. 46–49. Paris. 4to.—Cartulaire Lyonnais. Par M. C. Guigue. Tome I. 1885.

Museum d'Histoire Naturelle. Rapports Annuels de MM. les Professeurs et Chefs de Service.—Nouvelles Archives du Muséum d'Histoire Naturelle. 2me Série. Tome IX. 1886.

Société Française de Physique. Séances, 1886–87. Collection de Mémoires relatifs à la Physique. Tomes II. et III. 8vo.—Mémoires sur l'Électrodynamique. 1885–87.

Société Philomathique. Bulletin XI. 1887.

Catalogue des Étoiles. 0^h–6^h. Tome I. 1887. 4to.—Positions observées des Étoiles. 1837–81. 4to.

Société Zoologique. Bulletin 1887.

Pennsylvania.—Annual Report for 1886.—Geological Relations of the Nanticoke Disaster. By C. A. Ashburner. 1887.—Geologic

Distribution of Natural Gas in the United States. By C. A. Ashburner. 1887.

Perthshire.—Society of Natural History. Vol. I. 1886.

Philadelphia.—Proceedings of the American Philosophical Society for Promoting Useful Knowledge. Nos. 124–126. 1886–87. 8vo.

Proceedings of the Academy of Natural Sciences for 1886–87.

Poulkova.—Nicolai-Hauptsternwarte. Jahresbericht für 1884–85. 8vo. —Zeitstern-ephemeriden auf das Jahr 1886.—Tabulæ Quantitatum Besselianarum. 1885–1889.

Die Beschlüsse der Washingtoner Meridian-Conferenz. Von O. Struve.

Prague.—Astronomische und Magnetische Beobachtungen an der K. K. Sternwarte zu Prag., in 1886.

Queensland.—Its Resources and Institutions. Vol. I. 1886. 8vo.

Queensland Branch of the Royal Geographical Society of Australasia. Vol. II. 1887.

Weather Charts. By C. L. Wragge, Brisbane. 1887.

Rhineland and Westphalia.—Verhandlungen des Naturhistorischen Vereines der preussischen Rheinlande u. Westfalens. See Bonn.

Rome.—Atti della R. Accademia dei Lincei. Rendiconti. 1886–87.—Memorie. Classe di Scienze Mor. Storiche et Filol. Serie IV.

Memorie della Società degli Spettroscopisti Italiani. 1886–87. 8vo.

Atti dell' Accademia Ponteficia dei Lincei, 1886–87. 8vo.

Rousdon Observatory.—Meteorological Observations for 1887.

St Petersburgh.—Bulletins de l'Académie Impériale des Sciences de St Pétersbourg. Tomes XXXI. 1886–87. Mémoires de l'Académie. Impériale des Sciences. Tomes XXXIV.–XXXV. 1886–87. 4to.

Journal Russkago Phisico-Chimicheskago Obtschestva. Tom. XVIII. 1886. 8vo.

Otchet Imperatorskago Russkago Geographicheskago Obtschestva. 1887. 8vo.

Beobachtungen der Russischen Polarstation an der Lenamündung. Theil II. Meteorologische Beobachtungen.

Annalen des Physicalischen Central-Observatoriums. Jahrg. 1883–84–85.

Repertorium für Meteorologie, herausgegeben von der Kaiserlichen Akademie der Wissenschaften. Bd. VIII. 1883. 8vo.

Comité Géologique. Bulletins, Vol. VI. 1887.—Mémoires. Vol. IV. 1887. 4to.

Salem.—Essex Institute. Bulletin of the Essex Institute. Vol. XVIII. 1886.

Peabody Academy of Science. Vol. II. 1886.

Shanghai.—Journal of the China Branch of the Royal Asiatic Society. N. S. Vols. XXI.–XXIII. 1886–87. 8vo.

Steiermark.—Mittheilungen des Naturwissenschaftlichen Vereines. 1886. 8vo.

Strasbourg—Inaugural Dissertations. 1887.

Stuttgart.—Jahreshefte des Vereins für vaterländische Naturkunde in Württemberg, Jahrg. 1886. 8vo.

Switzerland—Nouveaux Mémoires de la Société Helvétique des Sciences Naturelles. Band XXIX. 1885.

Comptes Rendus et Actes de la Société Helvétique des Sciences Naturelles, réunie à Genève, 1886, à Frauenfeld, 1887. 8vo.

Société Géologique Suisse. Revue XVI. 1886.

Sydney—The Proceedings of the Linnean Society of New South Wales. Second Series. Vols. I.–III. 1886–87. 8vo.

Journal and Proceedings of the Royal Society of New South Wales. Vol. XX. 1886. 8vo.

Australian Museum. Catalogue of the Fossils, 1883. 8vo.—Notes for Collectors of Specimens of Natural History and Geological Specimens. 1887. 8vo.—Descriptive Catalogue of the Medusæ of the Australian Seas. 1887. 8vo.—Catalogue, with Notes of Minerals, by A. F. Ratte. 1885. Geology of the Vegetable Creek Tin Mining Field. 1887. 4to.

Tacubaya.—Observatorio Astronomico. Annuario 1887.

Tasmania.—Proceedings of the Royal Society of Tasmania for 1886-87. 8vo.

Tiflis.—Magnetische Beobachtungen. 1884–85. 8vo.

Meteorologische Beobachtungen. 1885. 8vo.

Toronto.—The Canadian Journal and Proceedings of the Canadian Institute. New Series. Vol. IV. 1887. 8vo.

Toulouse.—Annales de la Faculté des Sciences. Tomes I.–II. 1887–88.

Trenton.—Journal of the Natural History Society. 1887.

Trieste.—Bolletino della Società Adriatica di Scienze Naturali. Vol. IX. 1886.

Tromsö.—Tromsö Museum Aarshefter. No. X. 1887.

Turin.—Memorie della Reale Accademia delle Scienze di Torino. Serie Seconda, Tom. XXVII. 1886. 4to.—Atti della R. Accademia delle Scienze di Torino. Vol. XXII. 1887.

Bolletino dell' Osservatorio della Regia Università di Torino. Anno 1886.

Bolletino di Zoologia ed Anatomia Comparata della Università di Torino. 1886–87.

Upsala.—Bulletin Météorologique Mensuel de l'Observatoire de l'Université d'Upsal. Vols. XVII.-XVIII. 1885–86. 4to.

Nova Acta Regiæ Societatis Scientiarum Upsaliensis. Ser. 3^a. Vols. XII., XIII. 1885–86.

Utrecht.—Verslag van het Verhandelde in de Provinciaal Utrechtsch Genootschap van Kunsten en Wetenschappen, 1885.—Aanteekeningen van het Provinciaal Utrechtsch Genootschap. 1885. 8vo.

Venice.—Atti del Reale Istituto Veneto di Scienze, Lettere ed Arti. Ser. VI. Tomi IV., V. 1886–87.

Victoria.—Transactions and Proceedings of the Royal Society of Victoria. Vols. XXII., XXIII. 1886–87.

Victoria.—Statistical Register and Australian Statistics for the years 1886–87, with a Report by the Government Statist.

Natural History of Victoria. Prodromus of the Zoology of Victoria. Decade I. 1888.

Victorian Year-book for 1885–86.

Vienna.—Denkschriften der K.-K. Akademie der Wissenschaften. Math. Naturwissenschaftliche Classe. Bd. LI., LII. 1886–87.—Philosophisch-historische Classe. Bd. XXXV. 1886.

Sitzungsberichte der Math.-Naturwissenschaften Classe. Bde. XCIII.–XCIV. 1886.—Philosoph.-Historische Classe. Bde. CXII.–CXIV. 1883–85.

Archiv für Oesterreichische Geschichte. Bde. LXVIII.–LXX. 1886–87.

Almanach der K.-K. Akademie der Wissenschaften für 1886. 8vo.

Jahrbücher der K. K. Central Anstalt für Meteorologie und Erdmagnetismus, Jahrg. Neue Folge; für 1884–87. 4to.

Verhandlungen der K. K. Geologischen Reichsanstalt. 1886–87.

Abhandlungen der K. K. Geologischen Reichsanstalt. Bd. XI. 1886–87. 4to.

Jahrbücher der K. K. Geologischen Anstalt. Bde. XXXVI., XXXVII. 1887.

Verhandlungen der K. K. Zoologisch-Botanischen Gesellschaft. Bde. XXXVI., XXXVII. 1886–87.

Annalen der K. K. Naturhistorischen-Hofmuseums. Bd. II. 1887.

Arbeiten aus dem Zoologischen Institute. Tom. VII. 1887.

Virginia University.—Annals of Mathematics. Vol. III. 1887.

Warwick.—Proceedings of the Warwickshire Field Club. 1886. 8vo.

Washington.—National Academy of Sciences.—Memoirs. Vol. III. 1886.

United States Naval Observatory. Astronomical and Meteorological Observations made during the year 1883. 4to.—Report, 1886–87.

Astronomical Papers of the American Ephemeris and Nautical Almanac. Vols. II., III. 1884–85.

Signal Service Office—War Department.—Report of the Chief Signal Officer, General W. B. Hazen, for 1885–86. 8vo.—Professional Papers of the Signal Service. No. 18. 1885.

Fourth Annual Report of the Bureau of Ethnology to the Secretary of the Smithsonian Institution. 1882–83. 8vo.

American Geographical Society. Nos. 1–7. 1886.

Fifth and Sixth Annual Reports of the United States Geological Survey. 1883–84, 1884–85. 8vo.

United States Geological Survey. Monographs. Vol. X. (Dinocerata). 1882–83. 4to.—Vol. XI., Geological History of Lake Lahonton. 1885–86.

Washington.—Bulletins. Nos. 30–39. 1886. 8vo.—Mineral Resources of United States. 1886.

Reports of the Superintendent of the United States Coast and Geodetic Survey during the Year 1885. 4to.

Philosophical Society. Bulletins. Vol. IX. 1887.

Smithsonian Miscellaneous Collections. Vols. XXVIII.–XXXI. 1882–88. 8vo.

Smithsonian Contributions to Knowledge. Vol. XXV. 1885.

Smithsonian Reports for 1885. 8vo.

Bulletin of the Philosophical Society of Washington. Vols. VII.–IX. 1885–87. 8vo.

Wellington.—Transactions and Proceedings of the New Zealand Institute. Vol. XIX. 1887.

Reports of Geological Explorations (New Zealand) during 1885–87, with Maps and Sections. 8vo. (*From the New Zealand Institute.*)

Colonial Museum and Geological Survey. Twentieth, Twenty-First, and Twenty-Second Annual Reports. 1884–87.

Studies in Zoology for New Zealand Students. 1887.

Census of New Zealand, taken in 1886.

Wisconsin.—University Observatory. Observations. Vol. V. 1887.

Wurzburg Universität.—Über Sehnerven Degeneration und Sehnerven Kreuzung. Von Dr J. Michel. 1887.

Yorkshire.—Geological and Polytechnic Society. Vol. IX. Pt. 2. 1887.

Zurich.—Vierteljahrsschrift der Naturforschenden Gesellschaft in Zürich. 31^er^ Jahrg. 1886. 8vo.

II. FROM AUTHORS, &c., 1885–87.

Academy of Science Minutes. Minutes of the Academy of Physics (Edinburgh, 7th January 1797 to 10th February 1798). 4to. (*From Claude Erskine, Esq., London, through Sheriff Æneas Mackay.*)

Albrecht. Verläuft der Nervenstrom in nicht geschlossener, oder geschlossener Strombahn. Erlangen, 1887. 8vo.

Balbin (Valentin). Elementos de Calculo de los Cuaterniones y sus Aplicaciones Principales á la Geometria, al Analisis, y á la Mecanica. Buenos Ayres, 1887. 8vo.

Bischoffsheim (M.). L'Observatoire de Nice (a Series of Photographs of the Buildings, Instruments, &c.) Folio. 1888.

Bowman (F. H.), F.R.S.E. Report on Wools (Colonial and Exhibition Papers). 1886.

Buist (John B.), M.D., F.R.S.E. Vaccinia and Variola: a Study of their Life History. London, 1887. 8vo.

Burns (Edward), F.S.A. Scot. The Coinage of Scotland. Illustrated from the Cabinet of Thomas Coats, Esq. of Ferguslie, and other Collections. Vols. I., II. Text; Vol. III. Plates. Edinburgh, 1887. 4to. (*Presented by James Coats, Esq., junior of Ferguslie.*)

Deuchar (David). The Progress of Life Assurance Business in the United Kingdom. Edinburgh, 1888. 4to.

Eccles (A. Symons). The Physiological Effects of Massage, &c.—Sciatica —Sleeplessness. London, 1887. 8vo.

Fairley (T.), F.R.S.E. On the various Forms of Filter Pumps or Water-Jet Aspirators. Manchester, 1887. 8vo.

Fievez (Ch.). Recherches sur le Spectre du Carbone dans l'Arc Électrique, en rapport avec le Spectre des Comètes et le Spectre Solaire. Brux. 1885. 4to.

Grewingk (Professor C.). Lebensbild des Prof. C. Grewingk. 1887. 8vo.

Hann (Dr Julius). Bericht über die Fortschritte der Geographischen Meteorologie. [1886.] 8vo.

Hinde (Dr George Jennings). On the Organic Origin of Chert in the Carboniferous Limestone Series of Ireland. London, 1887. 8vo.

——— The Microscopic Structure of the Malm or Firestone Rock of Merstham and Godstone, Surrey. 1886. 8vo.

Kölliker (Professor A. von). Ueber die Entwicklung der Nägel Würzburg, 1888. 8vo.

——— Ueber die Entstehung des Pigmentes in den Oberhautgebilden. Leipzig, 1887. 8vo.

Laurie (A. P.). Experiments on the Heats of Combinations of the Metals with the Halogens, as determined by Measurements of their Electromotive Forces in specially constructed Voltaic Cells. 1886. 8vo.

Lediard (Henry A.). A Test for the Presence of Iodine in the Body. 1882. 8vo.

——— Dislocation of the Elbow Backwards, with Fracture of the Coronoid Process. 1884. 8vo.

——— Fibro-Cystic Myoma of Uterus Septicæmia. 1884. 8vo.

——— Salmon Disease. 1884. 8vo.

Lieblein (J.). Handel und Schiffart auf dem Rothen Meere in alten Zeiten: nach Aegyptischen Quellen. Kristiania, 1886. 8vo.

Lockwood (Professor Samuel). Raising Diatoms in the Laboratory. New York, 1886. 8vo.

M'Gregor (James Gordon). An Elementary Treatise on Kinematics and Dynamics. London, 1887. 8vo.

Mallet (F. R.). A Manual of the Geography of India. Part IV. Mineralogy. Calcutta, 1887. 8vo.

Marilaun (A. Kerner v.). Studien über die Flora der Diluvialzeit in den Oestlichen Alpen.

Monaco (Le Prince Albert de). Deuxième Campagne Scientifique de "l'Hirondelle" dans l'Atlantique Nord, 1885. Paris, 1887. 8vo.

——— Les Recherches Zoologiques poursuivies durant la seconde Campagne Scientifique de l'Hirondelle. 1886. 4to.

——— Sur une Expérience entreprise pour déterminer la Direction des Courants de l'Atlantique, 2e Campagne de l'Hirondelle. Paris, 1887. 4to.

——— Sur la troisième Campagne Scientifique de l'Hirondelle.

Monaco (Le Prince Albert de). Sur des Courbes Barométriques enregistrées pendant la Troisième Campagne Scientifique de l'Hirondelle. Paris, 1887. 4to.

Nicholson (J. Shield). The Measurement of Variations in the Value of the Monetary Standard. London, 1887. 8vo.

Nipher (F. E.). The Volt, the Ohm, and the Ampere. St Louis, 1888. 8vo.

Saint Lager (Dr). Histoire des Herbiers. Paris, 1885. 8vo.

Stevenson (Charles A.). On the Dredging of the Lower Estuary of the Clyde. London, 1887. 8vo.

——— Description of the Electric Light on the Isle of May. London, 1887. 8vo.

Velschow (Franz A.). The Natural Law of relation between Rainfall and Vegetable Life, and its application to Australia. London, 1888. 8vo.

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leave to England, where he arrived in February 1854. He next obtained the post of engineering superintendent of the Arthington Extension Waterworks under Mr Hawkesley, with whom he remained till the completion of the work, when he received a flattering letter from Mr Alderman Hepper, chairman of the Leeds Water Works Committee, expressing the great satisfaction of that body with the manner in which he had conducted the works. Returning to London, Mr Rumble experienced some difficulty in finding employment to his taste, and was, for short periods, draughtsman in the offices of Messrs Conybeare and Brikinshaw, the London and South-Western Railway Company, the Admiralty, &c., till in 1857 he was appointed engineer to the Atlas Steel Works, then entirely in the hands of Mr (now Sir) John Brown, in which capacity he was entrusted with the conduct of many transactions requiring much tact and diplomacy. In 1858 Mr Rumble was elected Fellow of the Society of Engineers; in 1860 a member of the Institute of Mechanical Engineers; in 1861 a member of the Institute of Naval Architects; and in 1866 a Fellow of the Royal Microscopical Society, in the proceedings of which body he was always deeply interested.

During these years Mr Rumble had opened an office in Westminster, and was practising as a civil and mechanical engineer, and was fortunate enough to secure much good work. In 1869 he paid a second visit to the United States, and spent six months visiting many engineering shops and acquiring a thorough knowledge of the recent mechanical improvements. Shortly after his return to England, Mr Rumble had the honour of two interviews with his late Majesty the Emperor Napoleon, who was pleased to express his satisfaction with the plans, drawings, &c., submitted for his approval. On New Year's Day, 1872, Mr Rumble was again in New York, and visited the various Safe Deposit Companies in that and other cities, with the view of obtaining information for the National Safe Deposit Company, then about to be formed in London. He visited Philadelphia, Boston, Halifax, &c., and the ruins of Chicago, then scarcely cold after the great fire, and examined the vaults and safes remaining intact. He returned to London on the 28th January, and was for the rest of the year employed in designing the safes, strong-rooms, buildings, and other arrangements of the National Safe Deposit Company, which were afterwards carried out under his superintendence at the corner of Queen Victoria Street. The extravagance of his partner at this time considerably involved Mr Rumble, and in 1875 he dissolved the partnership. In 1876 Mr Rumble obtained the position of chief engineer of the Southwark and Vauxhall Water Company. His unceasing energy and untiring industry gradually brought this company, from the state of confusion in which he found it, to such a state of order that the dividends rose from 2½ to 7½ per cent. In 1877 he was admitted member of the Institution of Civil Engineers. In 1878 he successfully laid a 30-inch main under the Thames at Richmond without the aid of dams—the only feat of the kind accomplished at that date in England. Under Mr Rumble's direction a trench was dredged across the bed of the river a few feet below Richmond Bridge. The lengths of the pipe, made on the ball and socket principle, were joined on the banks of the river, and in the early morning of July 3rd were shipped on board three barges strongly lashed together, carefully brought into position, and safely lowered into the trench. When the necessary connections at either end were made, the main was charged, and has ever since been in full work. During the year 1879 the Directors of the Southwark and Vauxhall Water Company determined to supplement the supply of water derived from the Thames by sinking a well into the chalk. In conjunction with Professors Prestwich and Ansted, Mr Rumble selected a spot in the Manor Park, Streatham; a trial bore-hole was made, and in 1881 the sinking of the well begun. The work is still in progress, but so far fully justifies the hopes formed for its success. Struck by Mr Rumble's manner of handling the matter, and entirely without his knowledge, Professor Prestwich and Professor Ansted proposed him as Fellow of the Geological Society, into which he was admitted in December 1879. In February 1881 he was elected Fellow of the Royal Society of Edinburgh.

Towards the end of 1881 the excessive overwork and heavy responsibilities of his position began to tell on his health, which steadily though very gradually failed, and he developed symptoms of pernicious anæmia which defied every effort to overcome it. In December 1882 Sir William Jenner recommended immediate and absolute rest of body and mind for six months. Leave of absence being unanimously granted by the directors of the company, various places were visited in search of health, until on the 5th

April 1883 he returned to Bonchurch, Isle of Wight, where he rapidly grew worse, and died on Saturday, 21st April, surrounded by nearly all his family. He was buried in the New Churchyard, Bonchurch, on 28th April.

Mr Rumble was twice married, and has left a large family to mourn his loss. In business Mr Rumble was straightforward and unerringly honest to his employers, often nervous about small matters, but without fear in cases of grave import, when he was always calm and self-possessed. The rapidity and clearness of his perceptive faculties amounted almost to the gift of second sight, and led him to form swift conclusions which rarely proved false. His firmness in dealing with faults in those under his charge was moderated by great kindness to his men when suffering under any affliction, illness, or distress. He was considered by them always more as a friend than master, and they showed their appreciation of his goodness by presenting him with a testimonial on the celebration of his 50th birthday, 26th December 1882. In private life Mr Rumble's genial spirits, shrewd observations, and witty remarks, endeared him to a large circle of friends. Indeed, his critical condition was almost to the last concealed by his courageous efforts to appear better than he was, and thus relieve the anxiety of his family. He possessed a most retentive memory, and had the faculty of readily assimilating those portions of the books he read which were likely to be useful to him in his professional work. His travels over the greater part of Europe and America naturally enlarged his ideas, and he drew full benefit from the varied experience thus acquired. He had deeply studied the legal as well as the technical points of his profession, and so was particularly well fitted to fill the various appointments he held during his lifetime.

JOSEPH LIOUVILLE. By Professor Chrystal.

Joseph Liouville was born at St Omer on the 24th March 1809. He came of a family of Lorrainers, more than one of whom were distinguished for talents beyond the common. Liouville's father held a public office under the Empire, and an elder brother, Felix Silvestre Jean Baptiste, was a distinguished Parisian advocate. Joseph gave early indications of mathematical ability, and entered upon that stereotyped course of training which has been famous for the nurture of so many Frenchmen of genius. At the age of sixteen he entered the École Polytechnique, and on leaving it in 1827 was classed as an engineer in the Department of Roads and Bridges. After two years he forsook engineering for the cultivation of the higher mathematics. He speedily distinguished himself in his chosen career; for as early as 1829 we find a paper of his ("Démonstration d'un Théorème d'Éléctricité Dynamique") in the *Annales de Chimie et de Physique;* and in 1831 he became a repétiteur, and seven years later a professor, in the Polytechnic School. In the interval he had performed perhaps his greatest service to his favourite science by starting in 1836 *The Journal de Mathématiques Pures et Appliquées.* This journal came most opportunely to fill the gap left by the discontinuance of the *Annales de Gergonne;* but it could scarcely have attained its brilliant success had it not been for the many excellent qualities of its editor, whose critical discernment, that enabled him to enter so readily into the spirit of the works of other mathematicians, and to assist at the *debut* of so many men of distinction,—whose amiability, candour, and freedom from national prejudice,—whose own inexhaustible powers as a contributor of original memoirs, all combined to fit him uniquely for the post which he filled so admirably for nearly forty years.

In 1839 Liouville was elected a member of the Academy of Sciences in succession to Lalande, and the year following he was put upon the Board of Longitude, in whose proceedings he took a lively interest to the end of his life. In 1852 he became a professor in the College de France, and continued to lecture in that capacity until about a year before his death.

If we except his continually recurring successes as a teacher and as an investigator in the most recondite of all the sciences, and the honours accorded to him by the scientific world in token of their appreciation, Liouville's public career was uneventful, as the career of a devoted man of science usually is. On one occasion, however, he departed from the "even tenor of his way." In 1848, a year of much tribulation for France, he received a flattering mark of widely spread popular esteem by being elected a member of the "Constituent Assembly." He promptly answered this call of public duty, and served his alloted time with efficiency if without special distinction. When, however, his mandate expired, instead of seeking re-election, he betook himself once more to the uninterrupted pursuit of the career for which his abilities best fitted him.

Liouville was as fortunate in his private life as he was successful in his public career. He lived to a good old age in the happiest domestic circumstances, until a cruel accident deprived him of his wife. His son, a councillor in the Court of Nancy, died soon afterwards, and the aged mathematician never completely recovered from the effects of this double bereavement. Although his health gave way, his intellect remained unclouded; and it was only in the beginning of 1882 that he gave up his favourite work of lecturing at the College de France. He still continued, however, to attend the meetings of the Academy, but expressed to his friends his consciousness that the end was near. He died on the 8th September 1882, as he himself said, "in his turn"; for, since the death of Chasles, he had been the patriarch among European mathematicians.

Some idea of the extent of Liouville's mathematical writings may be obtained by consulting *The Catalogue of Scientific Memoirs* published by the Royal Society of London. The entries under Liouville's name number 379, and cover some twelve pages. Many of these are merely remarks made on contributions to his journal, or notes appended to works by other mathematicians which he edited; yet, brief as they are, they frequently contain matter of much importance. As specimens of this part of his work, we may mention his "Notes on Two Letters of Mr Thomson relative to the Employment of a New System of Orthogonal Coordinates in certain Problems in the Theories of Heat and Electricity, and in the Problem of the Distribution of Electricity on the Segment of a Spherical Shell of Infinite Thinness" (*Jour. d. Math.*, xii. 1847), in which he draws attention to the analytical and geometrical importance of the method of Inversion, which had just been brought under the notice of mathematicians by the brilliant use that Thomson had made of it in his physical researches.

In another note (*Jour. d. Math.*, xv. 1850) he enunciates the important theorem that the equation

$$dx^2 + dy^2 + dz^2 = \lambda(d\alpha^2 + d\beta^2 + d\gamma^2),$$

where x, y, z, λ are functions of α, β, γ, has for its unique solution the stereographic or inversion transformation.

The following rough analysis will give some idea of the territory covered by his more elaborate memoirs :—

One of the earliest subjects that engaged his attention was Generalised Differentiation ("Différentielles à Indices Quelconques"). The subject is developed at considerable length in five memoirs printed in the 13th and 15th volumes of the *Journal de l'École Polytechnique* (1832–37).

Some of his most important work relates to the Integral Calculus, more particularly that part of it which deals with the theory of elliptic and other transcendental functions.

The earliest memoirs on the subject are two in the *Journal de l'École Polytechnique* (xiv. Cah. 1833, see also *Comptes Rendus*, 1837), "On the Determination of Integrals whose value is Algebraical." He here follows up the researches of Abel on the same subject; and arrives, *inter alia*, at the following important results :—

1. If χ be any rational function of x, then $\int dx\sqrt[m]{\chi}$, if algebraically expressible at all, can be expressed in the form $P\sqrt[m]{\chi}$, P being rational. And, farther, that the integral $\int dx\sqrt[m]{\chi}$ can always be reduced to the form $\theta/\sqrt[m]{T}$, where T is a known rational integral function, and θ a rational integral function whose coefficients have to be determined. This theorem enables us at once to find the value of the integral, if it is algebraically expressible; or else to show that it has no finite algebraical value.

2. If y be an algebraical function of x, *i.e.*, connected with x by means of an equation $F(x, y)=0$, which is rational and integral in both x and y, then, if the integral $\int ydx$ is expressible explicitly in finite terms by means of algebraic, exponential, or logarithmic functions, it will be expressible in the form

$$\int ydx = t + A\log u + B\log v + \ldots\ldots + C\log w;$$

where AB . . . . C are constants, and t, u, v, ... w algebraic functions of x.

Among the other memoirs on the present subject may be mentioned the following :—

"On the Elliptic Transcendents of the First and Second Species, considered as Functions of their Amplitude." *Jour. Éc. Polytech.*, xiv., 1834, and *Jour. de Math.*, v., 1840.

"On the Integration of a Class of Transcendent Functions." *Jour. de Math.*, xiii., 1835.

"On a New Use of Elliptic Functions in Celestial Mechanics." *Jour. de Math.*, i., 1836.

"On the Classification of Transcendents, and on the Impossibility of Expressing the Roots of certain Equations as a Finite Function of their Coefficients." *Jour. de Math.*, ii., 1837.

"On a very Extensive Class of Quantities whose value is neither Algebraic nor reducible to Algebraic Irrationals." *Jour. de Math.*, xvi., 1851.

Relating to the theory of differential equations, we have the following:—

"On the Equation of Riccati." *Jour. de l'Éc. Polytech.*, xiv., 1833.

"On a Question in the Calculus of Partial Differences." *Jour. de Math.*, i., 1836.

"On the Development of Functions or Parts of Functions in Series, whose various terms satisfy the same Differential Equation of the Second Order containing a Variable Parameter." Three Memoirs. *Jour. de Math.*, i. and ii., 1836–37.

"On the Integration of the Equation $\frac{du}{dt}=\frac{d^3u}{dx^3}$." *Jour. de l'Éc. Polytech.*, xv., 1837.

"On the Theory of Linear Differential Equations, and on the Development of Functions in Series." *Jour. de Math.*, iii., 1838.

"On the Integration of a Class of Differential Equations of the Second Order explicitly Infinite Terms." *Jour. de Math.*, iv., 1839.

Some of Liouville's most important work was in the department of applied mathematics. When, in 1834, Jacobi enunciated his theorem that an ellipsoid with three unequal axes is a possible figure of equilibrium for a mass of rotating fluid, and challenged the French mathematicians to give a proof, Liouville at once published one in the *Journal de l'École Polytechnique*, xiv., 1834. He afterwards returned to the problem, and, in continuation of the work of Meyer on the same subject, showed that Jacobi's form is not possible unless the ratio of the angular momentum to the mass exceeds a certain limit.—*Comptes Rendus*, xvi., 1843; *Jour. de Math.*, 1851.

In the *Journal de Mathématiques* for 1855 we have a farther contribution to this branch of hydrodynamics in the memoir entitled "General Formulæ relating to the question of the Stability of the Equilibrium of a mass of Homogeneous Liquid rotating uniformly about an Axis." The memoir, "On a passage of the *Mécanique Celeste* relating to the Theory of the Figure of the Planets" (*Jour. de Math.*, ii., 1837), in which he points out and corrects an error of Laplace, should also be mentioned.

On dynamics we have three memoirs in vols. xi., xii., and xiv. of the *Journal de Mathématiques*, dealing with certain cases in which the equations of motion of a material point, or of a system of such, can be integrated. The equations are transformed by the substitution of various systems of generalised coordinates (mostly elliptic coordinates), and then the form of the Force Function (Potential) is so specified that integration in finite terms shall be possible. The third of these memoirs, which deals with a system of material particles, is interesting mainly as regards the theory of Abelian integrals. In addition to these there are memoirs, "On a particular case of the Problem of Three Bodies," *Jour. de Math.*, i., 1856; and "On Developments of a chapter in Poisson's *Mécanique*," *Jour. de Math.*, iii., 1858.

Liouville made several contributions to Planetary Theory, among which which we may specially mention his memoir, "On the Secular Variations of the Angles between the straight lines that form the Intersections of the Orbits of Jupiter, Saturn, and Uranus." *Jour. de Math.*, iv., 1839.

In a variety of scattered notes are to be found some very important additions to our knowledge of Theoretical Dynamics. Perhaps the most striking of these is that "On a Remarkable Expression of the Quantity which in the Movement of a System of Material Particles connected in any way is a minimum in virtue of the principle of Least Action." *Jour. de Math.*, 1856. If we take the case of a single free particle, and use Cartesian coordinates, Liouville's result for the form of the integral which expresses the action is—

$$A = \int d\theta \sqrt{\left\{ 1 + \frac{\left(\dot{y}\frac{d\theta}{dz} - \dot{z}\frac{d\theta}{dy}\right)^2 + \left(\dot{z}\frac{d\theta}{dx} - \dot{x}\frac{d\theta}{dz}\right)^2 + \left(\dot{x}\frac{d\theta}{dy} - \dot{y}\frac{d\theta}{dx}\right)^2}{\dot{\theta}^2} \right\}}$$

where θ is a function of xyz, which satisfies the equation

$$\left(\frac{d\theta}{dx}\right)^2 + \left(\frac{d\theta}{dy}\right)^2 + \left(\frac{d\theta}{dz}\right)^2 = 2(E - V).$$

Liouville gives this theorem in terms of generalised coordinates for any system of particles, and points out that it opens up a new method of treatment leading readily to all the known results of Theoretical Dynamics.

During the latter part of his life, Liouville's researches were almost entirely directed to the Theory of Numbers. From 1857 to 1873 we have a list of over 200 notes and memoirs on this subject, all published in his own journal. A few occur with earlier dates, for examples the following:—

"On the equation $Z^{2n} - Y^{2n} = 2X^n$." *Jour. de Math.*, v., 1840.

"On a Theorem of the Indeterminate Analysis." *Comptes Rendus*, x., 1840.

"On the Two Forms $x^2 + y^2 + z^2 + t^2$, $x^2 + 2y^2 + 3z^2 + 6t^2$." *Jour. de Math.*, x., 1845.

The most important of all the memoirs on this subject are the series entitled "On some General Formulæ which may be useful in the Theory of Numbers." *Jour. de Math.*, vols. iii.–viii., New Ser., 1858–1863.

Very few of the longer memoirs are devoted to Pure Geometry; but many interesting and novel geometrical theorems occur incidentally in Liouville's mathematical writings. A full account of these will be found in the third chapter of Chasles' "Report on the Progress of Geometry in France."—*Recueil de Rapports sur l'État des Lettres et les Progrès des Sciences en France*, Paris, 1870.

We may mention here some of the results arrived at in two memoirs, "On certain general Geometrical Propositions, and on the Theory of Elimination in Algebraical Equations (*Jour. de Math.*, vi., 1841), and "Developments of a Geometrical Theorem" (*Jour. de Math.*, 1844). The following results among others are arrived at:—

1. The points of contact of a geometrical surface with all the

tangent planes parallel to a given plane have a fixed centre of mean position whose position is independent of the direction of the given plane.

2. The centre of mean position of the meeting points of two algebraical curves is also the centre of mean position of the meeting points of the asymptotes of one of them with the other or with its asymptotes.

3. If through the points of intersection of a curve and a circle normals to the curve be drawn, these normals intercept on a transversal through the centre of the circle segments measured from the centre, which are such that the sum of their reciprocals is zero.

If the circle be drawn to touch the curve at P, and we take for the transversal the normal at P, this proposition gives us a construction for the centre of curvature at P.

4. Considering all the tangents to a curve parallel to a given line. The centre of mean position of the points of contact is the centre of mean position of the interventions of the asymptotes.

The centres of curvature corresponding to the points of contact have the same centre of mean position as the points of contact themselves; the sum of all the corresponding radii of curvature is zero, and the same is true of the sum of their inverses.

5. Considering all tangent planes to a surface parallel to a given plane, the sum of the principal radii of curvature at the points of contact is zero, and the same is true of the sums of their reciprocals.

The work of the scientific teacher is scarcely less important than that of the scientific investigator, although the record of the former is more perishable, being at best an oral tradition handed over by the immediate disciples of the master. It would appear that in this walk Liouville was worthy to rank with his illustrious predecessor Monge, whose pupils shed such lustre on the French school of mathematicians. M. Faye, in his funeral oration, says, "M. Liouville was one of the most brilliant professors that ever lectured. So lively was my youthful impression of his lectures that to this day I have a vivid recollection of the captivating clearness that was so peculiarly his own. Accordingly, when in later years I had the good fortune to hear him speak at the Institute, I was the less surprised at the effect which his words produced on my colleagues, who marvelled at being able, for a moment, under his guidance, to penetrate the most difficult questions of the higher analysis. No one, with the exception perhaps of Arago, ever produced this effect in the same degree."

His lectures at the College de France were attended by the *élite* of French mathematicians, and doubtless did much to keep alive the ardent spirit of pure mathematical research which still lives among his countrymen. Among those who either were his pupils or were indebted to his encouragement and patronage may be reckoned Le Verrier, Hermite, Bertrand, Serret, Bour, Bonnet, Mannheim, all of whom are or have been pillars of French science.

If we compare Liouville as an investigator with other great contemporaries whose rolls of achievement like his own are already closed, we can scarcely put him in the highest rank of all, along with Abel and Jacobi, whose fortune it was in the course of their discoveries to open up new fields of research and create new branches of the analytic art. Nevertheless, so profound are some of his isolated contributions, and so elegant is all his mathematical writing, that it will be long before the traces of his handiwork vanish from the fabric of mathematical science; and it seems certain that future generations will accord him all but the highest rank in the temple of mathematical fame.

ROBERT WILSON. By Professor Fleeming Jenkin, F.R.SS. L. and E.

Mr Robert Wilson was born in 1803 at Dunbar. In 1810 he lost his father, who was connected with the royal and mercantile navies. This brave man, after having twice reached the wreck of the "Pallas" frigate in the Dunbar life-boat, was drowned in the third attempt to reach the ship and rescue the remainder.

Mr Robert Wilson was apprenticed to a joiner, and, like many other distinguished Scotchmen of the same generation, he owed his high standing as a mechanical engineer almost entirely to his natural genius, since he does not appear to have received any special advantages in respect of education.

During his apprenticeship, and at a date considerably prior to the successful introduction of the screw propeller into our navy, he made models of boats with various forms of screw, which worked successfully. He himself considered that the first idea of the screw propeller had occurred to him as a mere child; his first model was that of a ship 2½ feet long, and a drawing which he published of it in later life shows a very good four-bladed screw propeller; he attempted unsuccessfully to drive this by a windmill on the boat. In 1821, after seeing the "Tourist" paddle steamer, he made some further experiments, but having to leave the sea coast he dropped the subject. In 1825 he returned to Dunbar, and again attacked the problem, trying first four blades, then three, and then two, driven by the main-spring of a clock. At first the screw was placed in front of the rudder, and the sketches since published by Mr Wilson show the exact arrangement now usually adopted. He abandoned this plan, however, in consequence of leakage at the stern tube; and in order to get the opening above water line he used two single blade right and left propellers immersed for less than half their diameter and driven in opposite directions, being placed one behind the other, and connected by bevel wheels.

In 1827 young Wilson was introduced to the Earl of Lauderdale, whose son saw a small boat about 3 feet being driven in this way. Lord Lauderdale appears to have brought the matter to the notice of the Admiralty, but the young inventor met with no encouragement in official quarters. He next exhibited his model before the Dunbar Mechanics' Institution. A record of the exhibition was made in the minutes of the institution for October 18, 1827; and the *Edinburgh Mercury* of the 29th December 1827 alludes to the invention. The Highland Society of Scotland in 1828 appointed a committee, which after seeing the small model made a grant of £10, to enable Mr Wilson to have propellers made on a larger scale. Consequently a boat 25 feet long was fitted with a pair of these screw blades, to be driven by two men with winch handles; the committee, which included two captains in the Royal Navy, reported very favourably on the performance of this boat, during a trip in Leith Roads, lasting 17½ minutes. The model became the property of the Highland Society.

In 1832 a committee of the Society of Arts reported favourably on the trial of another model 18 feet long, fitted with the same arrangement of two blades revolving in opposite directions. The prize committee of this Society awarded him a silver medal and a prize of five sovereigns, pointing out in their report that the stern paddles, as they call the propellers, "can be kept altogether under water and out of the reach of surf, and answer equally well in rough as in smooth sea."

Mr James Hunter of Thurston had introduced the invention successively to the Dunbar Institute, the Highland Society, and the Society of Arts. Notwithstanding the encouragement received from those Societies and the support given by various influential men, the Admiralty, to whom he again applied, declined to make any trial of the plan, and Mr Wilson had the mortification of seeing the simple screw introduced into the navy by Mr Smith of Hendon.

Mr Wilson was, however, by no means the first who had thought of a screw as the propeller of a boat, and it must be admitted that he pushed the right and left hand geared screws in preference to the simple plan which was ultimately successful. He met with some reward indirectly, becoming known to many influential persons as an ingenious and able young mechanic; and ultimately in 1880 he had the satisfaction of receiving a sum of £500 from the Admiralty for the use of his double-action screw propeller as applied to the fish torpedo.

In 1832 Mr Wilson was in business as an engineer in Edinburgh, in the North Back of the Canongate. A few years afterwards he went to Manchester, and in 1838 he was manager of the famous Bridgewater Foundry at Patricroft. That he should, with no educational advantages, have attained this position at thirty-five years of age, is perhaps as high a testimony to his ability as his connection with the screw propeller or even with his steam hammer itself. It is universally admitted that the conception of the steam hammer was due to Mr James Nasmyth, but Robert Wilson was the inventor of important details which he considered essential to its success. On the one hand, we must remember that a steam hammer at Creuzot, suggested by Mr Nasmyth's sketch, worked successfully with no assistance given by Mr Wilson; but on the other hand, there is no doubt that some details largely used in connection with the hammer, as commonly made in England, were due wholly or in great part to Mr Wilson. There was unfortunately some disagreement between him and Mr Nasmyth on this point; and indeed it is nearly impossible, when men are working together at the improvement of a machine, to appraise with any exactness the precise share of merit due to each.

The first steam hammer made in England was delivered to the Lowmoor Iron Works in 1843. Mr Wilson left Patricroft, and became engineer to the Lowmoor Works, where in 1853 he added what is known as the circular-balanced valve to the original machine. This invention was patented by Mr Wilson. In 1856, when Mr James Nasmyth retired from business to follow the scientific pursuits by which he has greatly added to his reputation, Mr R. Wilson was recalled to Patricroft, where he became the managing partner of Messrs Nasmyth, Wilson, & Co.

Mr Wilson did not take much part in local affairs, but was for some years president of the Patricroft Mechanics' Institution. In 1873 he was elected a Fellow of the Royal Society of Edinburgh. He continued to apply himself to the management of his works until his death, which occurred on the 28th July 1882.

A list of no less than thirty patents stand in his name, either solely or jointly with others.

Mr Wilson will be remembered as worthy of mention among the group of able Scotch mechanicians who, by their power of invention, energy, and business capacity, have not only won distinction and wealth for themselves, but have added to the resources and strength of the empire

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JAMES YOUNG, LL.D., F.R.S. By Dr Angus Smith.

James Young was born in Glasgow, and on leaving school was engaged for some time in a joiner's shop. It is characteristic of his energy that at this time he would, during his holidays, make long journeys on foot, having on one occasion walked as far as Aberdeen, and on another having walked the greater part of the way to London, visiting places of historic interest on his way. His occupation in the joiner's shop was the occasion of his becoming a chemist. He attended the class of chemistry in Anderson's College, and his skill as a workman led to his being employed by Professor Graham, who then taught the class, in constructing pieces of apparatus for the experiments. By his usefulness and intelligence he eventually became assistant to Professor Graham, and lectured when the Professor was absent. He held the assistantship for seven years, and accompanied Professor Graham to London when the latter obtained a chair in University College. Among his friends at Glasgow were Dr Stenhouse, F.R.S., Dr Lyon Playfair, and Charles Griffin, an eminent manufacturer of chemical apparatus.

Young now engaged in the great enterprise from which he became widely known as a public benefactor, and which was destined to bring him both fame and profit. One Mr Oakes mentioned to Dr Lyon Playfair that there was oil flowing from a pit at Alfreton in Derbyshire. Dr Playfair then told this to Young, who at once perceived what an improvement might be made in the system of domestic lighting by the utilisation of this natural product. The flow of petroleum, small though it was, from the source in question, and the results obtained from it by Young, were the means of leading the Americans to avail themselves of the vast supplies of this useful substance that are to be found in their own continent.

The discovery, however, with which his name is most intimately associated, was his mode of obtaining oils from coal and shale, by which he succeeded in producing an illuminant oil at a price which enabled him to compete with the oil that was latterly obtained in such quantities from the petroleum springs in America.

Young did not discover solid paraffin; two little bits had been produced before his time; but he saw that it could be profitably made on a large scale, and, by the methods he introduced, hundreds of tons of solid paraffin are now made annually, and by his improved processes in the manufacture of this article he has transformed the candle, as he had previously by the introduction of petroleum transformed the lamp.

He founded a chair for the advancement of Technical or Economic Chemistry in Anderson's College, Glasgow, whilst he liberally contributed to the endowment of professorships in other branches of science in that institution.

When he worked in the laboratory of Professor Graham, solid caustic soda, as now manufactured on a large scale, could only be made in small quantities in silver vessels. Dr Young first made it in iron vessels, and caused to be recalled an order for a silver vessel to cost £1500, by showing how that alkali could be prepared in iron.

He had the degree of LL.D. conferred on him, and became a Fellow of the Royal Society. He was elected a Fellow of this Society on April 1st, 1861. He was Deputy-Lieutenant for Kincardineshire. Though his successful enterprises had brought him wealth, he was unostentatious in his habits, and of a kindly and hospitable disposition. He died in May 1883.

JOHN MILLER, M.Inst.C.E.

Mr John Miller was born at Ayr on the 26th of July 1805. He was educated at the Academy of his native town, and on leaving it entered a solicitor's office; but feeling no liking for the legal profession, he determined to abandon it for that of a Civil Engineer. After making himself well acquainted with the theory and practice of engineering, he became a partner of Mr Thomas Grainger, M.Inst.C.E., whose office was in Edinburgh. Whilst in partnership with that gentleman, he was engaged in constructing roads in various counties in Scotland, and in the south of Ireland, and was acting engineer for the Dundee and Arbroath Railway; the Glasgow, Ayr, and Kilmarnock Railway; the Edinburgh and Glasgow North British Railway. He also designed and constructed the North British Railway, Edinburgh to Berwick, and the Edinburgh and Hawick Railway; the Dundee and Perth Railway; the Stirling and Dunfermline Railway. Mr Miller was also engineer for many other lines, both in Scotland and England. In November 1845 he deposited in Parliament plans for upwards of 1500 miles of railway.

On the above railways there are probably some of the finest viaducts in Great Britain, notably the Almond Valley Viaduct, consisting of 46 arches of 50-feet span; the Dunglass Viaduct, the centre arch of which has a span of 135 feet; whilst the centre arch of the Ballochmyle Viaduct has a span of 180 feet. Mr Miller, however, always considered the Lugar Viaduct, with nine arches of

50-feet span, and four of 30-feet span, as his greatest work. The rails of that viaduct are 150 feet above the River Lugar.

Mr Miller retired from the profession of Civil Engineer in 1850. In 1868 he was returned to Parliament as one of the members for the city of Edinburgh, but lost his seat at the General Election in 1874. He purchased the estates of Leithenhopes in Peeblesshire, and Drumlithie in Kincardineshire, and devoted a great part of his time to improving them. He died on the 8th May 1883.

Mr Miller at the time of his death was Senior Member of the Institution of Civil Engineers, and was elected a Fellow of this Society in 1841.

Charles Adolph Wurtz.

Charles Adolph Wurtz was born on November 26, 1817, at Wolfheim, in Alsace. He studied at the University of Strasburg, where he completed the medical curriculum by taking the Doctor's degree in 1843. From Strasburg he went to Paris, where he occupied several positions successively, until he became in 1883 Professor at the École de Médicine; and in 1866 he was made Dean of the Faculty. In 1867 he was elected member de l'Institut, in preference to Berthelot, who was his only serious opponent. He died on the 12th May 1884, having only three weeks previously pronounced a brilliant and affectionate *éloge* at the tomb of his great master Dumas, whose successor as perpetual Secretary of the Academy he was, on all sides, designated to be.

Few chemists have done more or more remarkable work than Wurtz. His first publication is on the nature of hypophosphorous acid, which he explained; and in the course of his studies on the compounds of phosphorus he discovered the oxychloride. In hydride of copper he discovered the first definite combination of hydrogen with a metallic body. In 1848 he made perhaps his most important discovery, namely, that of the compound ammonias, which did so much to assist in establishing the type-theory of his countryman and contemporary Gerhardt. It was extended by his discovery of glycol and the consequent introduction of the idea of polyatomic alcohols. The controversy on the constitution of lactic acid, in which Wurtz took an important part, had the effect of clearing up the distinction between the *atomicity* and the *basicity* of an acid. In 1855 he discovered the mixed alcoholic radicals by a method which has since become a standard one for the synthesis of hydrocarbons. His researches on *aldol*, a body uniting in itself the properties of an alcohol and an aldehyde, bring us down to the present date.

It would be impossible, in a notice of reasonable length, to give any adequate idea of the importance of the work done by Wurtz during the forty years of his active life of investigation, and it would be equally impossible adequately to appreciate the far-reaching effect which the school which he founded around him has had in the development of modern chemistry. Many of his most illustrious pupils remained to the last workers in his laboratory, influenced by the spirit of enlightenment with which he inspired all who came in contact with him. The personal charm which Wurtz exercised on all who were associated with him cannot be better expressed than in the words spoken at his grave by his distinguished pupil and attached friend Friedel. After extolling his rare powers as a lecturer, he says—"We see him in his laboratory, receiving with unwearying kindness even the humblest of his pupils, interesting himself in his work, and discussing his ideas as with an equal, sowing his ideas broadcast, and as happy and proud of a discovery made by one of his pupils as he was modest and unassertive of his own. Singularly open to new ideas, and afraid of no scientific speculation, however bold, provided it received the sanction of experiment, he was peculiarly fitted to promote the progress of science, and to lead it over firm and solid ground. It was owing to these rare qualities that he attracted so many chemists, both French and foreign, to his laboratory. Of these many in their turn have become masters, and all will unite in saying that the time which they passed in daily association with Wurtz counts amongst the happiest and most fruitful of their lives."

Sir A. Grant.

By the death of Sir A. Grant on the 30th November 1884 the Royal Society of Edinburgh lost one of its Vice-Presidents, who took a constant interest in its proceedings; the University lost a Principal who for sixteen years administered its affairs with remarkable ability and success, and who has left a more enduring mark on its history than any Principal during the present century; and the cause of liberal education in Scotland lost one of its most enlightened and consistent supporters. Although of Scottish extraction, he was, unlike all previous Principals of the University, neither born nor educated in Scotland; and when invited at the age of forty-two to assume his position in Edinburgh, he had already gained distinction, in two widely separate spheres of usefulness, as a scholar and writer on philosophy, as a teacher and lecturer, and as an administrator of education. From the time when his own University course was finished, his whole life was devoted to the practical work or to the organisation and administration of education: first, during ten years, from 1849 to 1859, in the University of Oxford; next, for nine years, from 1859 to 1868, in the Presidencies of Madras and Bombay; and finally, for sixteen years, from 1868 to 1884, in the University of Edinburgh. In Oxford and in India, as well as in Edinburgh, his influence is still felt and his loss regretted by many friends.

By birth he belonged, on the father's side, to an old Scottish family, the Grants of Dalvey on Speyside. His mother was of mixed French and Scottish extraction, and was the daughter of a planter in the Danish West Indian Island of Santa Cruz. The family estate in Morayshire had been sold by his grandfather, and the whole fortune, which had been invested in West India property, had been lost before Sir Alexander succeeded his father as 8th Baronet in 1858. He was born in New York on the 13th September 1826, and passed two or three years of his childhood in the West Indies. The principal part of his school education was received at Harrow, which he entered in 1839, and left as head of the school in 1845. In November 1844 he had been elected to a Balliol scholarship, and he entered on residence at Oxford in the

Easter term of the following year. He came up to the University an excellent classical scholar of the type produced by the great English public schools, and with the social tastes and disposition which are fostered in those schools. He was especially eminent in Greek and Latin composition, and the faculty of lucid and graceful statement developed by these accomplishments proved of invaluable service to him in the various administrative duties which he was called upon in after life to perform. He combined with his scholarly attainments an appreciative taste for modern literature, and especially for the great English poets, and his interest in the philosophical, which are combined with the more strictly literary, studies of the University, and in the speculative questions by which Oxford life was powerfully stirred in the years succeeding the great religious movement of which Dr Newman was the centre, was soon awakened. He read widely and discriminatingly, but with no special eye for examinations; and thus it happened that his name is remembered among those of a select few (including Clough, Mr M. Arnold, Mr Froude, Mr Freeman, M. Pattison, and others), who, by their subsequent eminence, justified the opinion that the second class in *Litteræ Humaniores* often contained men of greater power and promise, if of less minute knowledge, than the first. He graduated in 1848, and in the following year he was elected, out of a large number of candidates, to an Oriel Fellowship. As circumstances had made it necessary for him to support himself from this time forward by his own exertions, he immediately became one of the private tutors, a class somewhat like that of the *privat-docenten* in the German Universities, who performed a much more important part in Oxford education in those days than they do at present. The preparation of the best men for their final examination in philosophy was almost entirely in their hands. Although most of them were men of older standing, he very soon was recognised as the most eminent of the body, and amongst his pupils were several men who have since obtained distinction in various walks of life, who acknowledged the benefit they derived from his instruction. He lived with his pupils on the most easy and familiar footing, and attached them to himself by his friendliness and social geniality. At the same time, he taught his subject—the Nicomachean Ethics of Aristotle—more thoroughly than it had been taught in England before his day. While fully realising the living interest which the book, regarded as a treatise on human nature, has for all times, he was one of the first to recognise the truth, now universally acted upon, that it was to be interpreted, not vaguely and arbitrarily in accordance with any theological bias or with the moral sentiment of our own time, but historically in accordance with the evolution of Greek thought and the conditions of Greek life, and with the whole system of the Aristotelian philosophy. The mature result of his study and teaching was his edition of the *Ethics of Aristotle*, the first volume of which was first published in 1857. It is on this work, of which a fourth edition appeared a few weeks before his death, that his reputation as a scholar and a writer on philosophy mainly rests. Though it is more than a quarter of a century since it was given to the world, and though during all that time the subject has been assiduously studied and taught at Oxford, his edition still remains the standard one, and among English scholars his name is as familiarly associated with the *Ethics of Aristotle* as that of Conington with Virgil, and of Munro with Lucretius. In proof of the estimate still formed of its merits by those who are constantly using it, I may be allowed to quote the words of one of the most competent among the younger tutors at Oxford. While admitting that the work is exposed to some criticism in the present day, he adds—"We are too apt not to realise how much such a work has done directly and indirectly for the appreciation of Greek philosophy in this country. It was the first and it still remains the only attempt in any language to unite a scholarly study of the very difficult text with a literary and philosophical appreciation of the treatise in its relation to the whole history of Greek thought. Certainly no one of the German editions attempts anything so extensive, and only one of them (in Latin) has a philosophical value." He goes on a few sentences later—"In Edinburgh his name will always be associated with a most brilliant period in the history of the University. Throughout the world of English-speaking scholars he will be remembered as one of those who have set before themselves and others an ideal of scholarship which excludes neither philosophical thinking nor a regard for literary excellence. We are sometimes apt to boast that this is a specially English or even a specially Oxonian ideal; we are too often reminded that few even endeavour to attain it, and any of these few can ill be missed." *

It is no paradox to say that even the defects of the work, such as they are, as well as the great merits which make it the best introduction to the study of Greek ethical philosophy, are connected with what was his greatest quality—the largeness and breadth of his nature. It was not possible for him to become a pure specialist—a mere scholar, or abstract thinker, or man of letters. A complete change in his circumstances, which took place shortly after the publication of this work, made it clear that he was rather a man of great general capacity, fitted to obtain success and eminence in any important province of life, than one born with the special bent and genius of a scholar or philosopher. During the last twenty-five years of his life it was to the sphere of action more than to that of thought and research that his energies were directed; and, however great may have been the loss to the University of Oxford, and to classical learning, caused by this diversion of his powers, there is little doubt that his own capacities were expanded by it, and that he was enabled to do more useful work in the world than if he had been appointed to the Professorship of Moral Philosophy in Oxford, for which he was an unsuccessful candidate in the year 1859. His marriage in that year with the daughter of Professor Ferrier of St Andrews, and the grand-daughter of "Christopher North," was the immediate cause of his seeking a new career in India, and was probably the remote cause of his final connection with the University of Edinburgh. He accompanied Sir Charles Trevelyan to Madras, and began his career in that Presidency as Inspector of Native Schools. From Madras he was soon called to the Presidency of Bombay, where in rapid succession he filled the posts of Professor of History and Political Economy in the Elphinstone College, of Principal of that College, of Vice-Chancellor of the University of Bombay, of Director of Public Instruction, and of Member of the Legislative Council in the Presidency. The best work of his life was probably that which he gave to India, during the nine years of his active employment there. His name was soon as familiarly associated with Bombay as it had been, and still is, with the *Ethics of Aristotle.* An important Government minute of the 3rd October

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* *Oxford Magazine*, January 21, 1885.

1868, after his appointment as Principal of the University of Edinburgh, affirms that he had "undoubtedly set his mark on the history of education in India." It adds—"While supporting the complete independence of the University, he used it as the crown of the Government educational system." In a despatch written about the same time to the Governor of the Presidency, the Duke of Argyll, then Secretary of State for India, speaks of "the solidity and reality of his administration," and concludes with expressing "concurrence in the just remarks recorded by your Excellency in Council, relative to the very valuable services rendered by Sir A. Grant to the cause of education in India." A minute of the University of Bombay, of the same time, speaks of "his ability in administration," of "his important suggestions and effective aid in the revision of the bye-laws of the University, especially as bearing on the extension, arrangement, and balance of studies," of "his temper and tact when discharging the duties of the chair," and of "his extensive influence with the public in the matter of endowments and beneficiaries." Great as his intellectual gifts of organisation and administration were, the power of his personality was still more remarkable. Along with his general interest in Indian education he combined a warm personal interest in individuals, and the aid which he afforded to the advancement of able and deserving men among them is still gratefully remembered by natives of India.

He entered on his duties in Edinburgh in the beginning of the winter session of 1868–69, and continued during the remainder of his life to perform them with ever-growing capacity and knowledge, and with the most loyal attachment to the institution to which he came as a complete stranger. With his sound practical sagacity he combined a high imaginative faculty, and while minutely attending to and mastering the details of business, he set constantly before himself the ideal of what the University ought to be as a nursery of intellect and character, and as an organ for the elevation of national life. He gained the entire confidence of his colleagues in the Senatus, whether they agreed or disagreed with him on particular questions, by the impression he produced of absolute devotion to the good of the University. He gained the regard and admiration of the students by his frank, dignified, and cordial bearing in all his relations with them, and by his genuine sympathy with them in their aspirations, their work, and their amusements. He wished every one to feel as he did, proud of his University, and determined to uphold its credit by intellectual effort and by honourable conduct.

Although the pursuits of the last twenty-five years of his life tended to force him into the groove of action, rather than of letters, yet they were by no means barren in literary results. In India, besides delivering several interesting addresses, which may still be read with pleasure and instruction, he was a frequent contributor to the English newspapers published in the Presidency. His recently published *History of the University of Edinburgh* is the most important literary product of his later years. Inspired and pervaded by his idealising love of his University, it is a work at once of learned research and of strong human interest in its record of many of those by whom the chairs in the University were filled at various times. His Lives of Aristotle and of Xenophon, undertaken for Blackwood's series of Ancient Classics, are written with scholarly taste and simplicity, and with that insight and vivacity of feeling which, without vulgarising it, can invest an ancient theme with modern meaning. His last address to the students, delivered only a few weeks before his death, affords more than his more elaborate works a true image of the man, in his intellectual power, his serious enthusiasm, his large-heartedness, the dignity and simplicity of his bearing. It produces an indefinable impression of greatness. His colleagues in the University, certainly, will always think of him as their "greatest, yet with least pretence."

No record of his career would be complete without some reference to the services which he rendered when a member of the Scotch Education Board. His most eminent colleague on that Board ascribes to him the chief credit in preparing the First Scotch Code, which was "a great improvement on anything of the kind previously prepared." He adds—"My own clear impression is, that no man ever knew about educational organisation from top to bottom better than Grant." His eminence as a scholar and administrator was recognised by the Universities of Oxford and Cambridge, of Edinburgh and Glasgow, which conferred on him their honorary degrees of D.C.L. and LL.D. The most enduring monument of his Principalship will be the New University Buildings, which owe more to his active services and his personal influence than to any other instrumentality. The great Tercentenary celebration of 1884 will, through all the future history of the University, be associated with his name. The conception of the celebration was altogether his, and its successful realisation owed more to him than to any one else. The shock of his unexpected death, on the 30th of November 1884, following so quickly on the memorable events of the preceding April, is still fresh in the memory of his colleagues in the University and in this Society.

JAMES NAPIER. By Robert R. Tatlock, F.I.C., F.C.S., F.R.S.E.

James Napier was born in the village of Partick, one of the suburbs of Glasgow, in 1810. His father was a hand-loom weaver in humble circumstances, and his mother was a sempstress. At the age of seven or thereby he was sent to a small day school in the village, kept by Mr Neil, a medical student, where in less than twelve months he learned to read with comparative fluency. On account of the straitened means of his parents, however, he was then sent to work, and found employment as a "tearer" in a calico printing works, his remuneration being 1s. 3d. per week. When he was between twelve and thirteen years of age he was put to his father's trade, and, being conscious of the limited character of his education, he endeavoured successfully to earn a little money, by extraneous efforts of various kinds, to enable him to attend a night school for two winters, by which his writing and knowledge of arithmetic were greatly improved.

Owing to dulness in the weaving trade, he betook himself to that of a dyer, and was employed by the Messrs Gilchrist at their works, Meadowside, Partick, where, at the age of eighteen, he was promoted to the post of foreman "piece dyer," his wages being then 11s. per week. When only twenty-one years of age he married, on the slender income of 13s. per week. About the year 1833, on account of the dull condition of the dyeing trade, a trades-union was formed among the workmen, in which he joined, and would not be dissuaded, even by offers of extra remuneration from his employers, in consequence of which he was dismissed. He was next employed as a dyer at Glasgow Field Bleach Works, where he remained for four years, after which, his health failing, he endeavoured to earn a subsistence by keeping a lending library, but without success, and ultimately returned to the dye-works where he was first employed, in the capacity of a clerk. Prior to this Mr Napier had written an essay of great excellence on dyeing, which had attracted the notice of the late Mr John Joseph Griffin, who combined the business of a dealer in chemical and philosophical apparatus with that of a publisher, in Glasgow, and afterwards in London. He accepted an appointment in this establishment to prepare and bottle chemical reagents, and to make up apparatus—an employment which he found very congenial, as in some autobiographical notes which he has left, he says:—" My position brought me into contact with all sorts of inquirers; people in different trades came, not only to buy apparatus, but to question about difficulties. I had access to all kinds of chemistry books, and gave willing search to help them, thus gaining a knowledge of different trades; but I wanted system, and to improve myself in this respect, I invited the members of our Mutual Instruction Society to my house, and went through a course of chemistry, following Graham's work. By these means, and by nightly study, I obtained a pretty good knowledge of the principles of the science." It was, doubtless, while in this employment that he made the acquaintance of the late Dr James Young, F.R.S., of Kelly, at that time laboratory assistant to the late Professor Graham, of Anderson's College, Glasgow, who afterwards became Master of the Mint, which resulted in a life-long and most friendly intimacy. In the year 1839 the results obtained by Mr Thomas Spencer in the new art of electrotyping and electro-metallurgy excited much interest, and Mr Napier, on Mr Griffin's account, carried out some laborious and important work with the object of applying the art to useful purposes, such as copying woodcuts and engraving plates, &c.; and in 1842 he was appointed to take a leading position in the London electroplating works of Messrs Elkington & Mason, where, it is needless to say, he discharged his duties in a manner which reflected the highest credit upon him, some of the work which he turned out being truly very fine. The interest he took in the process of copper-smelting led to the discovery of a great improvement in the refining and granulation of copper, by the application of soda ash, in which he encountered much opposition, notwithstanding which the process was taken up and wrought by a private company in 1847, who acquired the Spitty Works at Swansea for the purpose, the result of which was that at the end of the first year the books showed a net profit amounting to £19,000, or upwards of 55 per cent., £900 of which fell to Mr Napier's share. In 1844 he devised and described a process for extracting silver from its ores by calcination with common salt, which was, in principle, identical with the "wet process," devised by Mr William Henderson many years later, for the extraction of copper from poor ores. He also, some time thereafter, patented a method for the removal of tin, antimony, arsenic, &c., from poor Cornish ores. In 1852 he revised and extended some magazine papers which he had previously published, and they were published and issued by Messrs Griffin & Co., under the title of *A Manual of the Art of Dyeing.* This was succeeded by his well-known book entitled *A Manual of Electro-Metallurgy*, which in 1860 reached a fourth edition.

Mr Napier returned to Glasgow in 1849, and to his native place—Partick—in 1852, where he engaged in literary work and interested himself in its sanitary condition, analysing its potable waters, and instigating the movement which led to Partick being made a Police Burgh for its own local government. For several years he thus occupied himself, but retained his laboratory, employing himself as an investigating and consulting chemist. In 1860 he was requested by the Marquis of Breadalbane to visit and inspect a copper mine on his estate at Killin, on the south side of Loch Tay, which had been worked for years without profit, the result of which was that the works were started on the spot, under Mr Napier's superintendence, for preparation of copper regulus and the manufacture of sulphuric acid and artificial manures, but owing to the failure in the quality of the ore from the mine these were soon suspended. In 1861 he returned to Glasgow, and commenced business as consulting chemist, where he continued till 1864, when he erected sulphuric acid works at Vinegar Hill, near Glasgow, the operations of which occupied his time and attention for six or seven years. Being then relieved of the active management by his son, he returned to his literary pursuits, and soon produced his *Notes and Reminiscences of Partick* (1873), *Ancient Workers in Metals, Manufacturing*

Arts of Ancient Times (1879), and *Old Ballad Folk-Lore* (1879).

From the annexed list of his papers it will be seen that Mr Napier has earned for himself a recognised position in general science, and particularly in the special branches of technical chemistry and metallurgical science which were so congenial to him; and that, with a more liberal education, his mental activity and aptitude for scientific study would have won for him a great name in the scientific world.

Mr Napier was elected a Fellow of this Society in 1874. He was also a Fellow of the Chemical Society, and took much active interest in the local scientific societies with which he was connected, particularly the Philosophical, Natural History, and Archæological Societies of Glasgow. He was likewise a zealous worker in the management of Anderson's College, and of the "Young" Technical School, Glasgow, of which he was a trustee. The loss of his wife in the year 1881 proved a heavy blow to him, from which he never fully recovered; and on 1st December 1884 he terminated an active and useful life at the age of seventy-four, esteemed and respected by all who knew him.

BIBLIOGRAPHY.

1. On the Solubility of the Metals in Persulphate and Perchloride of Iron. *Chem. Soc. Mem.*, ii., 1843–45, pp. 16–20; *Phil. Mag.*, xxiv., 1884, pp. 365–370.
2. Observations upon the Decomposition of the Double Cyanides by an Electric Current. *Chem. Soc. Mem.*, ii., 1843–45, pp. 158–161; *Phil. Mag.*, xxv., 1844, pp. 779–881.
3. Observations on the Decomposition of Metallic Salts by an Electric Current. [1845.] *Chem. Soc. Mem.*, ii., 1843–45, pp. 255–260; *Archives de l'Electr.*, v., 1845, pp. 159–167; *Phil. Mag.*, xxvi., 1845, pp. 211–217.
4. Electricity Developed in Manufacturing Processes. *Walker's Electr. Mag.*, i., 1845, pp. 499–502.
5. On Electrical Endosmose. *Chem. Soc. Mem.*, iii., 1845–48, pp. 28–38; *Bibl. Univ. Archives*, ii., 1846, pp. 245–354; *Phil. Mag.*, xxix., 1846, pp. 10–21.
6. On the Unequal Decomposition of Electrolytes, and the Theory of Electrolysis. [1846.] *Chem. Soc. Mem.*, iii., 1846–48, pp. 47–53; *Phil. Mag.*, xxix. pp. 92–99.
7. On Copper Sheathing and the probable Cause of its Deterioration. *Glas. Phil. Soc. Proc.*, iii., 1848–53, pp. 161–173.
8. The Effects upon Health of inhaling the Fumes of Cyanide of Potassium Solutions. *Glas. Phil. Soc. Proc.*, iii., 1848–53, pp. 188–192.

9. Remarks upon Mineral Veins and Water-Worn Stones. *Glas. Phil. Soc. Proc.*, iii., 1848–53, pp. 231–238.
10. Remarks upon Sandstones used for Buildings, &c. *Glas. Phil. Soc. Proc.*, iii., 1848–53, pp. 313–322.
11. On Spurious Coins. *Glas. Phil. Soc. Proc.*, iii., 1848–53, pp. 344–350.
12. On Copper-Smelting. *Phil. Mag.*, iv., 1852, pp. 45–59, 262–271, 345–355, 453–465 ; v., 1853, pp. 30–39, 175–184, 345–354, 486–493.
13. Observations on the Trap Dykes in the Sea-Shore between the Bays of Brodick and Lamlash, in Arran. *Edin. New Phil. Jour.*, ii., 1855, pp. 81–83.
14. On the Action of Heat on Gold, and its Alloy with Copper. *Chem. Soc. Jour.*, x., 1858, pp. 229–233.
15. On Metallic Deposits found in two Chimneys attached to Reverberatory Furnaces, one being used for melting an Alloy of Silver and Copper and the other an Alloy of Silver and Gold. *Chem. Soc. Jour.*, xi., 1859, pp. 168–173.
16. On Incrustations in Steam Boilers. 1858. *Glas. Phil. Soc. Proc.*, iv., 1860, pp. 191–198.
17. Analysis of a small portion of Stone fused by Lightning. May 1854. *Glas. Phil. Soc. Proc.*, iv., 1860, p. 206.
18. On Trap Dykes between Condon and the south end of Whiting Bay, Island of Arran. *Glas. Phil. Soc. Proc.*, iv., 1860, pp. 321–324.
19. Black and Clayband Ironstones ; their Composition and Valuation. *Glas. Phil. Soc. Proc.*, v., 1864, pp. 210–217.
20. On the Cyanides of the Metals, and their Combination with Cyanide of Potassium. *Chem. Soc. Mem.*, ii., 1843–45, pp. 82–96 ; *Phil. Mag.*, xxv., 1844, pp. 56–71. (This paper was prepared conjointly by Mr Napier and Mr C. J. O. Glassford.)
21. On the Dynamics of the Galvanic Battery. *Phil. Mag.*, xxii., 1864, pp. 52–54.
22. Notes upon Dyeing and Dyed Colours in Ancient Times. *Glas. Phil. Soc. Proc.*, v., 1864, pp. 175–197.
23. On Ancient Mortars and Cement. *Glas. Phil. Soc. Proc.*, 1867, x. pp. 86–98.
24. Notes on Partick in Olden Times. *Glas. Archæol. Soc. Trans.*, i., 1886, pp. 256–271.
25. On some Popular Superstitions common in Partick forty years ago. *Glas. Archæol. Soc. Trans.*, i., 1868, pp. 391–398.
26. The Farmer and the Chemist. *Glas. Phil. Soc. Proc.*, vii., 1871, pp. 387–398.
27. On the Results of some Experiments on the Leaves of various Trees and Shrubs. *Glas. Nat. His. Soc. Proc.*, iii., 1878, pp. 105, 106.
28. Miscellaneous Notes in Natural History. *Glas. Nat. His. Soc. Proc.*, iii., 1878, pp. 194, 195.

Communications to the "Sanitary Journal."

1. On Damp Walls and Newly Built Houses. Nov. 1, 1876, i. p. 156.
2. The best Means of Drying the Walls of Newly Built Houses. Dec. 1, 1876, i. p. 162.
3. The Rivers Pollution Scheme. April 1, 1879, iii. p. 53.
4. Water Supply for Villas. Oct. 1, 1880, iv. p. 255.

PROFESSOR THOMAS CROXEN ARCHER. By J. D. Marwick, LL.D.

Thomas Croxen Archer, Director of the Edinburgh Museum of Science and Art, was born in Northamptonshire in 1817, and was educated in London as a surgeon. When about twenty-five years of age, however, he received an appointment in the Import Department of the Customs at Liverpool, and in that service he remained, receiving successive promotions, till 1856. Having a natural taste for botany, which he had zealously cultivated as a branch of his medical studies, Mr Archer took a keen scientific interest in all the vegetable imports of Liverpool, and when the authorities of that city were invited by the promoters of the Great Exhibition of 1851 to contribute to its success, and were puzzled to know how best to do so, Mr Archer proposed a scheme which met with universal acceptance. His suggestion was that Liverpool should be represented by a complete and systematically arranged collection of specimens of all the mineral, animal, and vegetable importations into the Mersey, and this scheme was admirably carried into effect under his own direction. He was subsequently invited to write one of the official reports on the Exhibition. The services rendered by him in connection with this collection, and also as agent in Liverpool for the Exhibition, were recognised by a medal; and in the following year he was appointed agent in Liverpool for the Crystal Palace Company, who marked their sense of the value of his work for it during 1852–3 by conferring three medals upon him. In the latter of these years Mr Archer contributed a volume on "Economic Botany" to a series of popular works on Natural History published by Lowell, Reeve, & Co., of London. About this time Sir William Hooker was forming the great museum of Economic Botany at Kew, and had much correspondence on the subject with Mr Archer, who afterwards set himself, with characteristic energy, to make a somewhat similar, though smaller, collection for the Royal Institution at Liverpool. His interest in botany also attracted him to the Botanic Gardens of the city, in which he took an active concern, and led to many excursions in the neighbouring counties, in the pursuit of his favourite study. He was appointed Lecturer on Botany in the Medical School at Liverpool, and afterwards Professor of Botany in Queen's College and in Blackburn College of the same city.

On 10th May 1860, Mr Archer became Director of the Edinburgh Industrial Museum, a name which was subsequently, by order of the Committee of Council on Education, changed into that of the Edinburgh Museum of Science and Art. The office had become vacant by the death of Professor George Wilson, who had done much, by the charm of his persuasive advocacy, to commend the objects of the museum to the public. But the state of his health, and the want of any suitable building in which the necessary collections could be exhibited, prevented much progress being made. Shortly after Mr Archer's appointment, however, the requisite steps were taken by the Government to proceed with the erection of a suitable museum, and in 1861 the foundation stone of the present building was laid by the lamented Prince Consort. To all the work connected with that ceremony—with the subsequent completion of the structure—with the transference to it of the collection made by Professor George Wilson, and also of his own private collection of upwards of two hundred specimens, chiefly of vegetable products used in the Arts—and with the supplementing and completing of these collections, Mr Archer devoted himself with untiring energy. What written appeals did not succeed in obtaining for the museum, personal solicitation at the various centres of industry rarely failed to secure. The enthusiasm of the director carried everything before it, and year after year he went over various countries in Europe, visiting important seats of manufacture and noteworthy art collections, and carrying back with him, as purchases or free gifts, the results of his untiring labours to enrich the museum at Edinburgh or South Kensington. When the eastern wing of the present building was completed, everything that Mr Archer could do to hasten on the extension of the central portion was done, and when the central portion was completed, no effort on his part was spared to induce the Government to complete the entire structure by the erection of the west wing now in progress. This he had the satisfaction of seeing commenced. In the arrangement and classification of the museum, as it now exists, and in the completeness with which every exhibit is made to tell its own story to the student, there remains, and will, it is to be hoped long remain, the evidence of Mr Archer's loving care and devotion to his work.

Mr Archer was appointed one of the jurors of the International Exhibition of 1862, and, along with Mr Peterson of the office of Crown Domains in St Petersburg, wrote an official report on the vegetable substances used in manufactures shown at that Exhibition. His services in relation to this work were acknowledged by a medal; and in the following year he was appointed a Corresponding Member of the Ministry of Crown Domains of Russia. He acted as Associate Commissioner at the Paris Universal Exhibition of 1867, and reported on the class of exhibits connected with forest products, for which report he received three medals. In 1870 he reported on the International Exhibition in London; and in 1871 he was commissioned by the British Government to attend the Exhibition at Moscow and Copenhagen. He was appointed a member of the Committee for Selection of the annual International Exhibition of 1872, for which Exhibition also he acted as Deputy Commissioner for Scotland. In 1873 he was appointed a juror at the Vienna Exhibition held in that year, and he prepared several reports for the British Commission in connection with it. His services at this Exhibition were acknowledged by the decoration of a Commander of the Order of Franz-Joseph of Austria. In the same year he was awarded the gold medal of the Russian Ministry of Crown Domains; and, in recognition of literary and scientific merit, was appointed Chevalier of the Order of St Hiago of Portugal. In 1876 Mr Archer was appointed Executive Commissioner for Great Britain and Ireland, along with Colonel Sandford, at the Philadelphia Exhibition of 1876, and in recognition of this service he was awarded a medal. In 1878 he acted as one of the jurors in the Paris Universal Exhibition of that year.

Mr Archer was connected with many literary and scientific societies. He was a director of the Royal Institution of Liverpool, a life member of the Liverpool Literary and Philosophical Society, an honorary member of the Liverpool Chemists' Association, a member of the Liverpool Microscopical Society (of which he was for several years secretary), an honorary member of the Birkenhead

Philosophical Society, a president of the Botanical Society of Edinburgh, a member of Council of the Royal Society of Edinburgh, and a member of the Royal Society Club, a president of the Royal Scottish Society of Arts, a secretary of the Edinburgh Microscopical Society, an honorary member of the Edinburgh Geological Society, a fellow of the Society of Antiquaries of Scotland, an honorary president of the Edinburgh Association of Science and Art, an honorary member of the Pharmaceutical Society of Great Britain, and an honorary member of the Pharmaceutical Society of Austria, the Philosophical Society of America, Philadelphia, and the Franklin Institute of Pennsylvania.

He was a liberal contributor to the *Transactions* of the various literary and philosophical societies with which he was connected, to the *Art Journal*, and *Journal of the Society of Arts*, to the eighth edition of the *Encyclopædia Britannica*, to *Chambers's Encyclopædia*, and to other works.

Called frequently to London on the business of his Department, Mr Archer had occasion to be there in February 1885, and had arranged to return to Edinburgh on the 19th of that month. Two of his daughters had joined him in the Midland Grand Hotel, and were proceeding to breakfast, intending afterwards to accompany him to the railway station, when, without premonition of any kind, he fell down in the hall and expired. He was predeceased in 1879 by his wife, and is survived by one son and four daughters. His eldest son and a daughter predeceased him.

Mr Archer was a man of great energy of character, and of wide and varied information. Throughout life he enjoyed exceptional facilities for becoming acquainted with an infinite variety of men and things in this country and abroad, and these facilities he utilised to the fullest extent. His retentive memory supplied him with inexhaustible sources of interesting conversation, and—underlying occasional apparent sharpness of manner—there were unfailing kindness, a high sense of honour, and, to those who knew him best, a depth and tenderness of feeling which were irresistibly attractive.

The writer of the present notice enjoyed Mr Archer's friendship for five-and-twenty years. He had the privilege of accompanying him in travels abroad, and enjoying his close friendship at home, and the result of that long and intimate knowledge entitles him to say that no more faithful public servant, no truer or more reliable friend, could be desired than Mr Archer was.

P.S.—Since this notice was prepared the writer has had placed in his hands the following letter from Colonel Donnelly, the secretary of the Science and Art Department, to Mr Archer's son:—

Science and Art Department.

3rd March 1886.

SIR,—The Lords of Committee of Council on Education have directed me to convey to you and the other members of his family their sense of the loss which has been sustained by the Science and Art Department by the death of Professor Archer.

My Lords deeply regret losing so valuable an officer; and, in desiring me to express their condolence with those who are mourning for him, have instructed me to place on record their appreciation of the exceptional zeal, energy, and ability with which he at all times discharged the important duties intrusted to him at the Edinburgh Museum of Science and Art.

They consider that it was mainly owing to his exertions that this Museum, which may almost be said to have been created by him, attained such popularity and importance since it was opened to the public under his direction in 1860.—I am, Sir, your obedient servant,

(Signed) W. D. DONNELLY.

CECIL ARCHER, Esq., 20 Greenhill
Place, Edinburgh.

JOSEPH MITCHELL.

Joseph Mitchell, civil engineer, for long resident in Inverness, and latterly in London, was born at Forres on the 3rd November 1803. His father, John Mitchell, was appointed, under Mr Telford, as inspector of works, in connection with the extensive road works, which, with the other great works then being carried out by Mr Telford, were the first means of opening up the Highlands to full access with the southern parts of Great Britain. Mr John Mitchell held the general inspectorship of the extensive system of communication known as the Highland Roads and Bridges. It is worthy of remark that Mr John Mitchell attracted the attention not only of Mr Telford, but also of the poet Southey, who wrote in terms of high commendation, both of his talents and moral qualities.

Joseph Mitchell seems in many respects to have inherited his father's energy and abilities. He was educated at the celebrated Academy of Inverness, which for many years was under the charge of the well-known Alexander Nimmo, C.E., who was long the personal friend of Telford and of Sir David Brewster, for whose *Encyclopædia* he wrote several articles.

Mr Mitchell became a Fellow of this Society in 1843. He became a civil engineer under the immediate auspices of Mr Telford, who caused him to engage in the practical masonry of the lockgates of the Caledonian Canal at Fort Augustus, after which Mr Mitchell not only became an apprentice in his office, but an inmate of his house, a striking proof of the high opinion which that great engineer had formed of his personal qualities. Here he made the first survey of the St Catherine Docks, which were carried out under Mr Telford's superintendence.

In 1824, when only twenty-one years of age, the whole of the Highland Roads and Bridges system was, on the death of his father, put under Mr Joseph Mitchell's charge, a fact which shows how great a trust was reposed in him by Mr Telford. During the long period of thirty-nine years he had these roads, extending over the rugged and difficult counties of Inverness, Ross, Cromarty, Sutherland, and Caithness, not only to inspect but to provide additional roads and bridges over the most difficult ravines and passes and the most formidable kind of rivers. There was in all this difficult country ample room for varied engineering practice, which was throughout of a most successful type. Besides all this Government work, he carried on an extensive private practice, involving the expenditure of about £180,000. He was also employed by Government to design and erect forty churches in outlying districts and lonely islands.

In 1828 he was appointed engineer to the Scottish Fishery Board, and designed and superintended the execution of very many useful harbours, as for example at Burnmouth, Coldingham, and Dunglass, in Berwickshire, at Buckhaven and Cellardyke on the Fife coast, as well as at various fishing stations on the coasts of Caithness and among the Hebrides. The large fishing harbour at Dunbar, which cost nearly £40,000, was also one of Mitchell's, as well as Lybster, on the Caithness coast, where, in order to avoid as much as possible conflict with the open sea, he preferred to recess the basin landwards of high water, instead of carrying the works outwards. He also designed improvements at Wick on the same principle. Mr Mitchell is well known as having been the engineer of the extensive work known as the Highland Railway between Perth and Inverness, as well as of most of the railways to the northward of Inverness. Mr Mitchell, in conjunction with Messrs William and Murdoch Paterson, was engineer for the Skye line.

Mr Mitchell has left behind him so many works of a varied, and some of them of a difficult nature, as to prove his natural sagacity and skill. He was always highly esteemed by his professional brethren for his geniality and high professional honour as well as his ability. True and genial as a friend, his death was felt by many as a personal loss, both in Scotland and in London, where he principally lived in later years. He died in London on 26th November 1883, at the advanced age of eighty years.

Professor HENRY CHARLES FLEEMING JENKIN. By W. H. P.

Professor Henry Charles Fleeming Jenkin, only child of Captain Charles Jenkin, R.N., of Stowling Court, Kent, and his wife (Cora Jackson), a Scotchwoman and a novelist of some mark, was born in Kent on the 25th of March 1833. Fleeming Jenkin was at the age of seven taken to Scotland, when he went to Dr Burnett's school at Jedburgh. There he stayed for three years, and then for other three years attended the Edinburgh Academy. In 1847 he went to school in Paris, where he saw the Revolution of 1848, of which he was wont to give vivid and interesting descriptions; and after the June riots he left for Italy, where he attended the University of Genoa in the Arts Faculty, taking his degree as Master of Arts in 1850. It was at Genoa also, in a locomotive shop, that he began his distinguished career as an engineer, under Philip Taylor of Marseilles. In 1851 he returned to England, and was apprenticed to Fairbairn's in Manchester for three years. His first practical work was done under Mr Hemans, on a survey for the Lukmanier Railway, in Switzerland; then he went to Messrs Penn at Greenwich; and then to Messrs Liddell & Gordon, in railway work. Thence he went to Messrs Newall (Birkenhead), while they were engaged on making the first Atlantic cable in 1857. He was very soon entrusted with the chief management of the Messrs Newall's engineering and electrical business. His work included superintendence of machine construction in the factory, the designing of picking-up and paying-out machinery, the fitting up of steamships for submarine cables and the electrical testing. This work he continued to do during the making of part of the first Atlantic cable, of the Red Sea cable, of a cable from Singapore to Batavia, and of several Mediterranean cables. In 1859, the year of his marriage with Ann, daughter of the late Mr Alfred Austin, C.B., he was elected Associate I.C.E., and began to write on scientific subjects, encouraged thereto by Professor (now Sir William) Thomson, whom he had first known through Mr Gordon, of Liddell & Gordon. In 1860 he took out a patent jointly with Sir William Thomson for signalling apparatus through long submarine cables, and in 1861 he entered into a partnership, which lasted seven years, with Mr H. C. Forde for general and telegraphic engineering. In the same year he acted as second in command under Sir William Thomson at the establishment of the British Association Committee on electrical standards. Of this committee he was appointed secretary, and he wrote their reports for several years. He also carried out most of the committee's important experiments in conjunction with Clerk Maxwell and others. He was juror for Physical Apparatus at the 1862 Exhibition, and was named Reporter for Electrical Apparatus. In 1865 the late C. F. Varley joined Sir William Thomson and Fleeming Jenkin in an agreement to work at the development of the signalling apparatus through long submarine cables already referred to. The apparatus devised by the three inventors was used by all the great companies, and Jenkin displayed a remarkable business faculty in the commercial management of the patent. In this same year Jenkin was elected a Fellow of the Royal Society, and in 1866 he was appointed Professor of Engineering at University College, London. In 1868 he dissolved partnership with Mr Forde, and resigned his post at University College, in order to accept the Chair of Engineering in Edinburgh University, which chair he filled until his death. After accepting this post he entered into a new partnership with Sir William Thomson, under the provisions of which Sir William and he acted as joint engineers to various submarine cable companies. Among the lines which were laid under their direction were those of the Western and Brazilian Telegraph Company, the Platino-Brazileien Telegraph Company, the West Indian and Panama Telegraph Company, and the Mackay-Bennett or Commercial Cable Company. In 1871 Fleeming Jenkin was President of the Mechanical Section of the British Association, which met that year at Edinburgh; and in 1873 he went to Brazil in the interests of the Western and Brazilian Telegraph Company. In 1877, in a lecture at Edinburgh given for the Edinburgh Philosophical Institution, he took occasion to propose the establishment of a Sanitary Protection Association. In consequence the Edinburgh Sanitary Protection Association was started, and succeeded so well that its example has since been followed in many parts both of Great Britain and of the United States. To most of these associations in Great Britain Fleeming Jenkin was consulting engineer. At the Paris Exhibition of 1878 he was juror in Engineering, and in 1884 was juror in Electricity in the Health Exhibition in London. From 1879 onwards to the time of his death he was Vice-President of the R.S.E., and from this Society he had the Keith Prize for the period 1877–79. This, the Society's highest distinction, was awarded for his paper on "The Application of Graphic Methods to the Determination of the Efficiency of Machinery," a continuation, full, however, of originality, of the subject treated in Reuleaux's *Kinematics of Mechanism.* In 1882 he took out his first patent for "Telpherage," a system of electrical carrying of burdens, or at need of passengers. The Telpher line is a conductor, which may be either flexible or rigid, of electricity supporting an electric motor and train of steps or of travelling chairs, which hang below it, and itself supported by strong posts. The line is in electrically distinct sections, and the train, itself a continuous conductor, and larger than any section, bridges over the interval between successive sections as it passes. The power is derived from a fixed engine and dynamos placed at convenient distance from the line. The "Telpherage Company," whose first working line was opened at Glynde, four months after Jenkin's death, which took place on the 12th of June 1885, was due to Jenkin's joining forces with Messrs Ayrton & Perry, who were, like him, turning their attention to the application of electricity to locomotion. His death was due to the unfortunate result of a surgical operation, slight in itself.

Apart from his own most special work, and from the sanitary engineering work which has been referred to, and which has had wide and good influence, Professor Jenkin took a deep and keen interest in Technical Education (he was for many years a Director of the Watt Institution) and in science generally. Witness among other instances his reviews of the Origin of Species (*North British Review*, June 1867) and of the Atomic Theory, an article supported by Munro's *Lucretius* (*North British Review*, 1868). Both Darwin and Munro, in subsequent editions of their works, acknowledged the value of Professor Jenkin's criticism. In the fine arts, and notably in dramatic art in its widest sense, his interest was equally keen and wide; but by the world at large, outside his own belongings and friends, he will be remembered best for his special and admirable work in electricity and engineering.

JOHN WATSON LAIDLAY.

John Watson Laidlay was born at Glasgow on the 27th of March 1808. At an early age he went to London, and began his education at a private school at Blackheath.

After passing through the ordinary curriculum there, he commenced a brief course of technical study, preparatory to going out to India, and with this view entered the laboratory of Faraday, by whom he was initiated in practical chemistry. At the same time he studied Hindustani under Dr Gilchrist, and it was here that he made the acquaintance of Bishop Heber.

This period was, however, very short; when he reached only his seventeenth year it was decided to send him out at once to India, and at this point his normal education may be said to have ended, his subsequent learning, the varied extent and scholarly accuracy of which was known only to his intimate friends, being entirely the result of self-imposed study.

In the end of 1825 he reached Calcutta, and joined his uncles, Messrs John and Robert Watson, merchants and indigo planters, Bengal, who subsequently purchased from the East India Company many of their best silk filatures and indigo factories, such as Berhampore, Rampore-Beauleah, Surdah, &c.

He was now constantly in charge of one or other of the filatures, and succeeded in introducing several valuable improvements in the machinery for winding silk.

His spare time he devoted to studying science and natural history, but, above all, the Oriental languages, for which he had a very decided talent; and, in addition to the native dialects, soon made himself familiar with Persian, Arabic, Sanskrit, and subsequently Chinese.

He originated the *Bibliotheca Indica*, a serial publication of native literature, which has proved a most valuable work, and is still continued.

His love of deciphering inscriptions on ancient monuments was great; and, with a view to assisting the labours of those engaged in this work in India, he translated *The Pilgrimage of Fa Hian* from the French edition of the *Foe Koue Ki*, with additional notes and illustrations of his own.

He made a valuable collection of coins, including many uniques; a portion of these were unfortunately stolen, but the remainder, together with his collection of shells, he presented to the British Museum.

His most numerous literary and scientific publications appeared from time to time in the *Journal of the Asiatic Society*, to which he acted as co-secretary, and afterwards vice-president and secretary to the Natural History Department.

He also compiled a comparative dictionary of Chinese words, and made translations of several Persian poems and other works, which were never published.

In 1839 he visited the Straits of Malacca for his health, and there he made the acquaintance of Rajah Sir James Brook. He went home to England in 1843, where he married, and returned the following year.

The remainder of his time in India, until his final return to England in 1850, was spent at Calcutta, where he associated with the leading scientific and literary men of the day, together with many other notable people.

On leaving India he gave up active work, and shortly settled down at Seacliff, Haddingtonshire, where he spent the remainder of his life.

He was now elected a Fellow of the Royal Society of Edinburgh, in whose proceedings he took a lively interest, although prevented by uncertain health from taking an active part in their meetings. He also became a member of various other societies in this country.

At all times of a retiring and unambitious disposition, he showed little inclination to enter society afresh and without the companionship of his former friends, but preferred rather to cherish and extend those kindred studies which had been so much to him in the past. In the quiet of his unostentatious life at Seacliff, he found a never-failing source of pleasure in his library, his laboratory, and in the wider field of nature. His was essentially a pure love of scientific truth for its own sake, and, although furnished with introductions which would have brought him in contact with many celebrated literary and scientific men, his extreme humility and modesty of self-assertion prevented him from availing himself of these opportunities of bringing his own learning into greater prominence.

Thoroughly versed in the classics, he delighted to read and re-read the works of the principal authors, most of whom he could quote at pleasure. Perhaps his favourite modern language was Italian, and Dante his favourite poet. Schiller and Goethe, too, he held in high esteem, while in our own literature he was intimately conversant with all the standard authors.

In the sciences, chemistry, archæology, geology, meteorology, and natural history, each afforded an inexhaustible field of research, his varied reading enabling him to keep abreast of the latest discoveries.

In medicine his knowledge was extensive and accurate, and so late as his seventieth year he attended, for his own pleasure, a whole winter course of anatomy at the Edinburgh University, under Professor Turner.

Some time before his death his eyesight began to fail, and thus he was reluctantly forced to abandon, one by one, his favourite studies; but his memory continued clear until his death, which took place upon the 8th of March 1885.

In private life he was esteemed by all who knew him for the gentleness of his disposition, his kindness and unvarying courtesy to all, rich and poor alike; but few, save his own family, knew his completely unselfish nature, his infinite goodness of heart.

The following papers are recorded under his name:—

On Catadioptric Microscopes. *Journal of the Asiatic Society*, vol. iii., 1834.

Analysis of Raw Silk. Vol. iv., 1835.

On the Rate of Evaporation in the Open Sea. Vol. xiv., 1845.

On the Coins of the Independent Mohammedan Sovereigns of Bengal. Vol. xv., 1846.

Sanskrit Inscription from Behar. Vol. xvii., 1848.

Daily Evaporation in Calcutta. *Ibid.*

Note on the Nido-Scythia Coins. *Ibid.*

Note on the Inscriptions found in Province Wellesley. *Ibid.*

Notice of a Chinese Geographical Work. Vol. xviii., 1849.

Note on an Inscription from Keddah. *Ibid.*

On Preparing Fac-similes of Coins, &c. *Ibid.*

On the Connection between Indo-Chinese and Indo-European Languages. *Journal of the Royal Asiatic Society*, vol. xvi. p. 59, 1856.

FRANCIS BROWN DOUGLAS, Esq. By Professor Duns, D.D.

Francis Brown Douglas was born at Largs, Ayrshire, April 2, 1814. His father was Mr Archibald Douglas, advocate, Edinburgh, and his mother was a daughter of Dr Francis Brown of St Vincent. He was educated at the Edinburgh High School, and for a short time in England. In early youth he went to the West Indies, where he was soon called to undertake the management of family estates. On his return to Scotland he studied for the Scottish Bar, and was admitted an advocate in 1837. He practised at the Bar for a short time only. Having an ample private fortune, he felt himself at full liberty to follow pursuits to him more congenial than the hard work of his profession, and accordingly he devoted his time and energy earnestly to municipal, philanthropic, and religious work. He was elected a Fellow of this Society in 1839. A man of general culture, he was intimately acquainted with several branches of current literature, and took a warm interest in public education. He was elected a member of the Edinburgh School Board when it was formed in 1872, and continued to serve in it till last election. Mr Brown Douglas entered the Edinburgh Town Council in 1850, and, after having acted as a magistrate for several years, he was chosen Lord Provost of the city in 1859. Two events occurred in the course of his Lord Provostship which may be mentioned, viz., the passing of the Annuity Tax Act, and the laying of the foundation stones of the New Post Office and the National Museum by the Prince Consort. Mr Brown Douglas was a Liberal in politics. He stood for the representation of the city in 1856, but was defeated. Later, he became a candidate for the St Andrews Burghs, but was again unsuccessful.

It was, however, chiefly in connection with religious and philanthropic work that he stood prominently out before his fellow-citizens. For more than forty years his name was associated with almost all movements of this kind. He threw himself with great earnestness and zeal into the Scottish ecclesiastical controversies that characterised the decade ending in 1843. He continued till the time of his death in August 1885 to take the most active and cordial interest in the work of the Free Church, both at home and abroad, and succeeded Mr David Maclagan in the convenership of its Continental Committee.

Mr Brown Douglas devoted a great deal of time and attention to some aspects of philanthropy which do not bulk largely in the public eye, but are full of good to many. He was for forty years president of the District Sick Society. He took an active share in the Society for Teaching the Blind in their own houses, in the Indigent Old Men's Society, and other kindred institutions—bringing, as director or as member, to their affairs sound practical wisdom, excellent business habits, wide views, keen sympathy, and helpful liberality.

Mr Brown Douglas was twice married—first in 1845, to Mary, second daughter of the late Charles Maitland Christie, Esq. of Durie, and again, in 1852, to Marianne, second daughter of the late Hon. Alexander Leslie Melville, who, with four sons and six daughters, survives him.

DAVID MACLAGAN, F.R.S.E. By Professor Duns, D.D.

David Maclagan was born in Edinburgh on the 9th of October 1824. His father, Dr Maclagan, a distinguished physician, had retired from the Army Medical Service after a noted career, and had settled down to a highly successful civil practice in Edinburgh. His mother was Miss Whiteside of Ayr. David was the fourth of seven sons, six of whom survive—Professor Douglas Maclagan, M.D., Dr Philip Whiteside Maclagan, Berwick-on-Tweed, General Maclagan, R.E., William Dalrymple Maclagan, Lord Bishop of Lichfield, John Thomson Maclagan, Secretary of the Church of Scotland's Widows' Fund, and Dr J. M'Grigor Maclagan, Riding Mill-on-Tyne. Mr Maclagan was educated at the Edinburgh High School. He began business life in the office of "The Scottish Union Insurance Company," and was appointed manager of "The Insurance Company of Scotland" in 1847. He was an original member of the Society of Accountants, a body which was incorporated by charter in 1854. Mr Maclagan removed to London in 1862, on his appointment as secretary to "The Alliance Fire and Life Insurance Company." In this position, his business associations brought him into close relations with the Rothschilds, Mr Goschen, Sir Moses Montefiore, and other well-known financiers. His acquaintanceship with Sir Moses soon ripened into intimate and lasting friendship. Mr Maclagan returned to Edinburgh in 1866, and entered on the managership of the Edinburgh Life Assurance Company, an office which he retained till his death on the 30th of March 1883, at Mentone, whither, for health's sake, he had gone to spend the winter. In 1848 Mr Maclagan married Miss Jane Finlay, who, with five sons, still survives.

On his return to his native city he threw himself with great heartiness and zeal into religious and philanthropic work. He was one of the most earnest promoters of the Apprentice School Association, a society which at the time did much good, both by supplying the means of education to a much neglected class, and also by leading the way to better arrangements for the same purpose. Mr Maclagan was elected a Fellow of this Society in 1872.

A man of academic tastes, fond of literature, the intimate friend of many engaged in literary and scientific work, and himself earnestly interested in the growth of knowledge, he yet found himself, in a great measure, precluded from practical literary effort by the onerous duties of his business position, and the devotion to work necessary to success in his profession. He had, however, as a relaxation and a delight, early cultivated the habit of the pen, and he has left good evidence of his scholarly accomplishments, intellectual vigour, and fine taste. From boyhood almost Mr Maclagan had taken great interest in Scottish religious and ecclesiastical movements. The stirring events which preceded and immediately followed the Scottish Church crisis of 1843 greatly influenced him. He entered into them with an earnestness and fervour in strong contrast with his wonted quiet and placid habits of thought. And though some rough points of his churchism may have afterwards been a good deal smoothed down, there was not, through life, any abatement of his early enthusiasm and zeal. Yet few men were freer from sectarian narrowness. His toleration for the views of others was as characteristic of him as the firmness with which he held his own. The writer, as Secretary of the Free Church College Committee, was associated for more than ten years with Mr Maclagan in work in which he had good opportunity to observe the breadth and the balance of his wellstored mind, the singular wisdom of his counsel, his sound judgment, and practical sagacity. Mr Maclagan was for many years a member of this Committee, and the Convener of its Finance Sub-Committee by which the Committee itself is guided in its administration of College property and finance. Reference is made to this to indicate the great business ability, tact, and shrewdness which Mr Maclagan brought to bear on it. Mr Maclagan was also for several years Convener of the Free Church's Continental Committee—an office which had been previously held by Sheriff Jameson, and, later, by Sheriff Cleghorn. He was an effective public speaker, and never spoke on any question of interest but when he had something to say, while his utterances were always clear, pointed, earnest, and telling. Notwithstanding the engrossment of business life, he did a good deal of literary work, mostly of a biographical kind. His last effort was a brief, but hearty, appreciative notice of his friend the late Mr Samuel Raleigh, written at the request of the Council of this Society. The death of Mr Maclagan was the removal from a wide circle of friends, and from the Fellows of this Society, of an accomplished Christian gentleman. In his able and touching "Memorial Sketch" of Thomas Cleghorn, "one of his dearest and truest friends," Mr Maclagan wrote of Sheriff Jameson in terms singularly applicable to himself:—"A mind well cultivated, and always fresh in thought and feeling—a decision in religious matters, thorough and uncompromising, united with a large toleration of the views of others—characterised him; while he was a lover of all good men, and the blithest of companions in hours of relaxation and social fellowship."

Dr JOHN ALEXANDER SMITH. By Professor Duns, D.D.

John Alexander Smith was born in Hope Street, Edinburgh, in June 1818. His father was the late James Smith, a well-known Edinburgh architect. Mr Smith was educated at the High School and the University of Edinburgh. While still a student he became a Fellow of the Royal Physical Society. He graduated in medicine in 1840, was elected a Fellow of the Society of Antiquaries of Scotland in 1847, a Fellow of this Society in 1863, a Fellow of the Royal College of Physicians in 1865, and succeeded the late Dr

Somerville in the Treasurership of the College in 1874. Dr Smith began practice as a physician, and continued in it through life, but his practice was never large. Possessed of means sufficient to enable him to follow his tastes for natural science and archæology, independently of professional income, these pursuits became the leading work of his life. But his professional brethren were never slow to acknowledge his skill in the diagnosis and treatment of disease. Had circumstances made it necessary to devote himself earnestly to his profession, it would hardly have been possible for him to have done half the work he accomplished in the literature of his favourite studies and in behalf of the Societies of which he was a Fellow.

When Dr Smith joined the Royal Physical Society it counted among its working Fellows, Knox, Captain Thomas Brown, Carpenter, Edward Forbes, Greville, Simpson, Goodsir, George Wilson, John Coldstream, Sir J. G. Dalyell, Charles Maclaren, and, later, Robert Chambers, John Fleming, Hugh Miller, and others who have done good work in Scottish Zoology and Geology. Dr Smith succeeded the late Sir Wyville Thomson as its Secretary, an office which he held for more than twenty years. In addition to his work as Secretary, he contributed many papers to the Society, some of much value. More than a hundred notices of birds, many of them new to Scotland, and some new to Britain, were written by him. In these he put on record all peculiarities as to time of visit, plumage, food, &c. In the *Proceedings* of the same Society are between twenty and thirty notices of fishes by him, including remarks on the divergence of some of the specimens from typical varieties in hermaphroditism, and other highly exceptional features. But he did not limit his observation to birds and fishes. Insects, reptiles, and mammals were described with equal interest and skill, while several mineralogical notices indicate his familiarity with this branch. On resigning the office of Secretary he was elected President, and in November 1876 delivered the address at the opening of the 106th Session of the Society. This address contains a complete list of his friend Dr Strethill Wright's numerous original papers on Protozoa and Cœlenterata, and in a somewhat incisive way he states his opinion of Darwinism, and frankly avows his belief in the doctrine of special creation and in the Bible views of the natural history of man.

On the 16th of April 1866 Dr Smith read to this Society a paper entitled "Description of Calamoichthys, a New Genus of Ganoid Fish from Old Calabar, Western Africa, forming an addition to the Family Polypterini." This paper, which is illustrated by two plates, is published in the *Transactions* for Session 1865–66. It affords an exceedingly good proof of Dr Smith's ability as a naturalist. Several specimens of both sexes were examined. The characteristics are precise, and embrace the minutiæ of every part, while much interesting information is given concerning the habits and food of these forms.

Dr Smith also contributed papers to the *Edinburgh New Philosophical Journal*, the *Annals and Magazine of Natural History*, and the *Journal of Anatomy*.

Dr Smith was Secretary of the Society of Antiquaries from 1852 till the time of his death, with the exception of two triennial periods, 1870–75 and 1875–78, when he held the office of Vice-President. Between 1850 and 1882, he contributed forty-five papers to its *Proceedings*. For many years he acted as joint-editor of the *Proceedings*, first in association with his intimate friend David Laing, and afterwards with Dr Arthur Mitchell. Dr Smith's archæological contributions are all interesting, and many of them valuable additions to the literature of Archæology. They illustrate the wide range of his knowledge. And all who were acquainted with his conscientious habits of study, with his devotion to true scientific method, and with the thoroughness of the investigation brought to bear on the subjects in hand, will not think it too much to affirm that he dealt with each of these subjects as if it only had ever held the chief place in his thought. His papers might be grouped thus,—Prehistoric Remains, Roman Remains, Mediæval Remains, Antiquarian Literature, Rock Sculpturings, and Archæo-Zoology. His contributions to the last group are very able and important. They bear emphatic testimony to Dr Smith's great attainments in Comparative Zoology. With characteristic precision he identifies the bones of mammal, bird, and fish, and skilfully uses the articles found in cave, or grave, or gravel heap in association with them, to serve for deductions touching the industrial conditions of the time, or for supplying a key to the age of the deposits themselves in which they occur. He did much, along with others who survive, to apply the recognised principles of historical criticism to antiquarian research, to free this branch of knowledge from the reproach of mere "curiosity hunting," and to give to Scotland a school of Archæology as thoroughly in the lines of true science as her school of Geology was held to be. This might be very fully illustrated by a criticism of his special contributions to this branch of study, such as the papers on "Roman Remains found near the Village of Newstead," or his "Notes on Melrose Abbey," or his "Notices of the Ancient Cattle of Scotland," or his "Notice of the Remains of the Reindeer found in Scotland." The last named is a peculiarly able and exhaustive paper. It is crowded with facts, which supply abundant material for trustworthy generalisations as to the climate and the inhabitants of the localities where the remains occurred.

In January 1883, Dr Smith began to suffer from the growth of a tumour in the upper jaw, which in a few weeks assumed a malignant form. But, both in the intense pain of the early stages of the disease, and in the rapid waste of the affected parts in the later ones, it was great satisfaction to his friends to see how calmly and bravely the Christian hope, which had long been his, enabled him to bear his sore affliction. He died on the evening of the 17th of August 1883.

Sir JOHN M'NEILL. By Professor Duns, D.D.

The Right Honourable Sir John M'Neill, G.C.B., third son of John M'Neill, Esq. of Colonsay and Oronsay, was born at Oronsay House, Argyllshire, August 12, 1795. He studied at the Universities of St Andrews and Edinburgh. Having graduated in medicine in 1815, he proceeded to India as an army surgeon. Four years later he was attached to the H.E.I.C.'s mission to Persia,—first in a medical and afterwards in a diplomatic capacity. His linguistic attainments, apt business habits, natural shrewdness, literary acquirements, and wide knowledge of Eastern affairs led to his appointment as assistant Envoy at Teheran in 1831. In 1834 he became secretary of the Embassy, and in 1836 he was appointed Envoy Extraordinary and Minister Plenipotentiary at the Court of the Shah—a position which he held for about six years. Soon after he became Ambassador an anonymous work on the influence of Russia in the East was published, and generally ascribed to Sir John. The work attracted a good deal of attention in England at the time. After his return home, he was appointed in 1845 chairman of the new Board of Supervision for Relief of the Poor in Scotland, an office which he held till 1868. While head of the Board of Supervision he made an extended tour of investigation, by desire of Government, through the Western Highlands, during the period of the famine. The Report which resulted from this tour was published in 1861. Characterised by much ability and great good sense, the Report is full of interest, both for the information it contains and for the remedial measures recommended in it, the chief of which, emigration, has recently been much canvassed in connection with the present social and industrial condition of the Highlands and Islands.

During the Crimean War, Sir John was requested by the Minister of War, Lord Panmure, to proceed along with Colonel Tulloch to the Crimea, and make careful inquiry into the disasters of that campaign in connection with the defective commissariat. On presenting the joint Report in 1855, Sir John received the thanks of Parliament and the distinction of G.C.B. He was sworn a member of the Privy Council in 1857. Though the accuracy of some parts of this Report was called in question by the military commission at home on the same subject, its value was generally admitted. Sir John was a D.C.L. of the University of Oxford, and LL.D. of Edinburgh. He was for some years one of the curators of the University of Edinburgh, and at the time of his death was honorary president of the Edinburgh Literary Institute. He became a Fellow of this Society in 1840, and was a member of many other learned societies, both British and foreign.

His latter years were spent partly at his residence, Burnhead, near Edinburgh, and partly at his villa, Poralto, Cannes, where he died on May 17, 1883.

Sir John was, by one of his marriages, brother-in-law of Professor John Wilson (Christopher North), and by his marriage in 1870 he became brother-in-law of the present Duke of Argyll.

MORRISON WATSON, M.D., F.R.C.P., F.R.SS. Edin. and Lond.

By Professor Alfred H. Young.

Among the losses sustained by the Royal Society during the past year, that occasioned by the sudden death of Dr Morrison Watson was perhaps the saddest.

In the prime of life, and apparently in good health, Dr Watson, when seized with the illness which soon afterwards proved fatal, was engaged in the active duties of the chair of Anatomy in the Owens College at Manchester, to which he had been elected—as the first occupant—eleven years previously. Prior to this, Dr Watson resided in Edinburgh, where he received—at the Queen Street Institution—his early education, and where later he studied medicine in the University, and in course of time took the degree of Doctor of Medicine. For some years he worked in the anatomical rooms of the University as demonstrator with Professor Goodsir, and thereafter with Professor Turner, by the latter of whom he was appointed to the office of principal demonstrator of anatomy. It was during this period that Dr Watson became a Fellow of the Royal Society, whilst more recently he was also elected a Fellow of the Royal Society of London.

By his friends, and he had many, he was regarded with feelings of the highest respect and esteem, and the news of his sudden and early death gave rise to widespread expressions of deep and sympathetic regret. To those who knew him best he was a genial and affectionate friend, and it was only those perhaps who could fully realise his sturdy independence of character, his straightforward nature, and the strength and depth of his friendship.

The loss which the Medical School of Manchester and the Owens College sustains by Professor Watson's death is great. He was appointed to the newly instituted chair of Anatomy, at the period when the amalgamation of the previously separate institutions, the Medical School and the Owens College, was effected, and he at once devoted himself with energy and vigour to the work of creating a School of Anatomy in Manchester. Under his direction the resources for teaching were greatly developed and materially augmented, and the now fairly complete collection in the Anatomical Museum of the Owens College was formed under his direct supervision. As a lecturer, Dr Watson was lucid and always practical. Alike by his own work, and by the generous encouragement he readily gave to others, he fostered a spirit for original investigation in the Anatomical School of the Owens College with such success, that it now occupies a prominent position amongst the English schools as one of the few in which, not only is human anatomy efficiently taught, but in which good work is also done in the wider field of animal morphology. It is to be hoped that in this respect the influence of Dr Watson's work will continue to exercise its power for good over the future of the anatomical department of the Medical School at Manchester.

Of Dr Watson's own additions to scientific anatomy, undoubtedly the most complete is the able and comprehensive contribution to the reports of H.M.S. "Challenger" (vol. vii., Zoology)—"On the Anatomy of the Spheniscidæ." An important memoir, "On the Anatomy of the Northern Beluga (*Delphinapterus Leucas*) compared with that of other Whales," of which he was joint author, appeared in the *Transactions of the Royal Society of Edinburgh* (vol. xxix.). A more recent paper by Dr Watson, "On the Female Organs and Placentation of the Raccoon," was communicated to the Royal Society of London (1881). The results of many of his investigations were communicated to the Zoological Society of London,—notably a series of interesting papers, "On the Anatomy of *Hyæna crocuta*" (1877–81); "On the Anatomy of *Chlamydophorous Truncatus*" (1879); "On the Muscular Anatomy of Proteles" (1882); and "On the Anatomy of the Indian Elephant" (1881–83). To the *Journal of Anatomy and Physiology* Dr Watson contributed articles, "On the Mechanism of Perching in Birds" (1869), which constituted part of a graduation thesis for which a gold medal was given; on "The Termination of the Thoracic Duct on the Right Side" (1872); "Notes on a Remarkable Case of Pharyngeal Diverticulum" (1874); on "A Case of Double Aortic Arch" (1877); on "The Homology of the Sexual Organs, illustrated by Comparative Anatomy and Pathology" (1879); on "The Curvatores Coccygis Muscle in Man" (1880); and a series of "Contributions to the Anatomy of the Indian Elephant" (1871–73). Dr Watson's remaining writings include papers on "The Anatomy of the Elk" (*Journal of the Linnean Society*, vol. xiv.); "Notes on . . . . two Species of Crustacea (*Ann. and Mag. of Nat. History*, 1870), and "Notes on Congenital Absence of the Kidney" (*Edin. Med. Jour.*, 1874).

Rev. FRANCIS REDFORD, M.A. By Henry Barnes, M.D.

The Rev. Francis Redford, M.A., who died on the 20th of last September, was one of the oldest and most notable clergymen in the diocese of Carlisle. He was born at York in 1813, and at an early period showed remarkable intelligence and aptitude for scientific work. He received his early education in the public schools of the city in which he was born, and afterwards, with the intention of adopting the medical profession, he entered King's College, London, as a medical student. After obtaining some considerable amount of medical training, which was very useful to him in after life, circumstances arose which made it desirable that he should adopt another career, and in 1837 he was sent out by the Church Missionary Society to Trinidad as a catechist. He remained in that country for four years, doing much good work, but owing to failure in health he was compelled to return to this country in 1841.

He then set about studying for the ministry of the English Church, and I am informed he was ordained deacon on June 11, 1843, by Charles James Blomfield, Bishop of London. He held curacies both in Herefordshire and Nottinghamshire, but a love of missionary work and travel induced him to again try the climate of the West Indies, and in 1844 he went out to Jamaica. A breakdown in his health compelled him to return in 1847. Three years later, in 1850, he was appointed to the living of St Paul's, Silloth, and here he continued to reside during the remainder of his life. Here it was that he made those observations on meteorology by which he will chiefly be remembered. At the time of his appointment, the now popular watering-place of Silloth was a desert of sandhills; there was not a single house there, and the part which he took in developing the place and promoting its prosperity is generally recognised. In the place of a sandy desert, there is now an important seaport, with its docks, pier, regular railway and steamboat communication, and abundant accommodation for visitors. By his meteorological observations, which were regularly published in the Reports of the Registrar-General and in the *Transactions* of the English and Scottish Meteorological Societies, of both of which he was a Fellow, he demonstrated the remarkable fact, that as regards the amount of ozone, signifying an absence of impurity, and in the amount of sunshine, Silloth occupied a very conspicuous position. This demonstration, proved by the careful record of many years' observations, has given Silloth a character which has undoubtedly contributed to its popularity as a health resort. He was the honorary secretary of the Cumberland and Westmoreland Convalescent Institution, from its foundation in 1862 to within a few weeks of his death, and by his energy and painstaking efforts in this capacity, he contributed materially to the success and prosperity of this valuable institution. His knowledge of botany was considerable, and he was an intimate friend of the late Professor Balfour. In the use of the microscope and telescope he was often engaged, and for many years he was a Fellow of the Royal Astronomical Society. The degree of M.A. was conferred upon him in 1860 by the Archbishop of Canterbury, and he was elected a Fellow of this Society in 1865.

Although he was in the daily habit of making scientific observations, I cannot find that he ever contributed any paper to our *Proceedings*. This is much to be regretted, as he had undoubtedly accumulated much valuable material, and the record of his labours in the department of meteorology fill many volumes. These have now come into my possession, and as I do not think a more fitting home could be found for them than the Royal Society of Edinburgh, I have much pleasure in handing them over for permanent preservation. In doing so it may be of service if I give a short account of the contents.

No. 1. A large volume of meteorological observations, taken daily at 9 A.M. and 9 P.M. from March 1854 to December 1868, giving the rainfall, wind, thermometer, hygrometer, and barometer. The ozone observations commence in April 1868. There is an interval of a few years, and the observations begin again in January 1874, and continue to December 1875.

No. 2. A volume containing observations of a similar kind, taken twice daily from January 1876 to January 1877.

No. 3. Twelve volumes containing detailed observations for the following years, viz., 1871, 1872, 1873, 1876, 1877, 1878, 1879, 1880, 1881, 1882, 1883, and 1884. The sunshine observations commence in 1881.

No. 4. A volume containing full observations from October 1876 to March 1877.

No. 5. A volume containing daily notes on thermometry and rainfall for 1869 and 1870, and monthly averages for 1872 and 1873.

No. 6. A volume giving a comparative statement of the rainfall, and readings of barometer and thermometer taken at Lewisham, Kent; Highfield House, Notts; and St Paul's Parsonage, Cumberland, from March 1854 to February 1855.

Together with these volumes there is another MSS. volume illustrative of the meteorological history of this district, which I desire to present to the Society at the same time. It is a volume of observations from January 1838 to May 1842, taken at Carlisle by the late William Elliot, M.D. Edin., and was found among Mr Redford's papers.

Before a Society like this, it would be out of place to refer to the manner in which he discharged his parochial and ministerial duties. Suffice it to say that he had many attached friends, that he found his chief relaxation in scientific studies, and that in a widely scattered agricultural community he could not find much companionship. The development of Silloth did much to give him, in this latter matter, much of what he formerly missed, and few of the scientific visitors left without visiting his observatory.

His health of late years had not been robust, but latterly symptoms of malignant disease of the abdomen set in. His last illness, which was of a painful character, was borne with great fortitude. No one knew better than himself there was only one possible termination, but amid his sufferings he found relief by turning to his scientific pursuits, and by the reflection that during the course of a long and active life he had accumulated observations that would be of value to his fellow-men.

General A. C. ROBERTSON. By T. Stevenson, *P.R.S.A.*

General A. C. Robertson, the eldest son of Lieutenant David Robertson, of Royal Marines, was born at Edinburgh, February 8, 1816, and was educated at the High School and University there. I knew him from boyhood as a born soldier, always ready to fight his battles with other boys under every circumstance of disadvantage, and when he found a difficulty in getting his commission he at once joined other volunteers from this country who took part in fighting against Dom Miguel in Portugal in 1834. Serving under Sir de Lucy Evans, he saw much heavy service with the British Auxiliary Legion in the north of Spain. He was present at the relief of St Sebastian and at the other battles which followed in quick succession during the years 1836 and 1837. At Ametza Robertson was severely wounded by a rock splinter from a round shot. He received for his services in Spain two medals and the cross of the first class of San Fernando. Robertson had risen to be captain in the Legion when, owing to some difference with his commanding officer, he threw up his commission and enlisted in another regiment, and rose again to be captain—a promotion which took place before he was one-and-twenty. In 1837 he obtained a commission in the 34th Regiment, serving with it for three years in Canada, having got his company in 1845.

In 1842–43 he had studied at the Senior Department, Sandhurst —the germ of the present Staff College,—and obtained superior certificates in mathematics and surveying. In April 1846 he exchanged into the 8th (the King's), with which he continued for the remaining twenty-nine years of his regimental service. A few days after the arrival of his regiment at Delhi, Robertson joined it there along with Colonel Baird Smith of the Engineers, and served in the siege till September 11, when the breakdown of his health compelled his being sent to the hills. Colonel Greathead says in his diary:—"Robertson was under fire from seven in the morning until six in the evening;" and again, regarding the mutiny, "The work was very well done, and the King's behaved very steadily under Captain Robertson, who is one of the bravest and coolest men under fire that can be seen." For his services during the mutiny he was mentioned in despatches, received the brevets of major and lieut.-colonel, a medal and two clasps; and after obtaining his lieutenant-colonelcy in 1865, he commanded the 2nd battalion of the King's—a post which he retained for nine years at Malta and in various home quarters. In 1876 he was nominated to the command of the 13th and 14th Brigade Depôts, retiring finally in 1878. He was gazetted C.B. on 2nd June 1877, and 24th March 1880 was appointed honorary colonel of the 15th Lancashire Rifle Volunteers.

After his retirement he lived chiefly in Edinburgh, and subsequently died at Liverpool, on 2nd December 1884, of a disease of an incurable and most painful nature, borne with singular patience and cheerfulness. Robertson was a man of much thoughtfulness, as well as a zealous soldier, and wrote with great independence on the following subjects:—Infantry; the tactics of the three arms; on the first three parts of the field exercises and evolutions of the army, and on some of the resemblances and differences between them and the corresponding part of the French ordnance, &c.; on the means of applying the principle of stimulating the voluntary exertions of individuals to the improvement of the system of military training; and a variety of other subjects connected with his profession. Besides which, he devoted his leisure for some years to a verse translation of "Jerusalem Delivered." In later years he re-edited the Historical Record of the King's Regiment. Robertson was therefore a man whom we may well be proud to reckon among our Fellows.

AUGUSTUS JOHN DARLING CAMERON. By T. Stevenson, *P.*R.S.A.

Augustus John Darling Cameron, the only son of the late John Cameron of Edinburgh, was born in October 1841, and was educated at the High School and University there. In 1860 he began an apprenticeship as a civil engineer with the late Mr John Paterson. He was subsequently in the employment of Messrs Foreman and M'Call, Glasgow, and Messrs Wylie & Peddie, and was engaged on railway and other works. He held an appointment of engineer in the India Office for several years, after which he was engineer to the South London Tramways Company, and under his superintendence the various lines of that company were constructed. He died on 27th November 1884. He was elected a member of the Institution of Civil Engineers in 1880, and a Fellow of this Society on 6th June 1881.

JOHN M'NAIR. By T. Stevenson, *P.*R.S.A.

John M'Nair was for nearly twenty years a Fellow of the Royal Society of Edinburgh. He took a lively interest in physical subjects, but owing to his advanced age, and the latterly feeble state of his health, was prevented from attending our meetings very regularly. He was born at Belvidere, near Glasgow, in 1801, and died at Edinburgh in his eighty-fifth year.

WILLIAM LINDSAY ALEXANDER. By Professor Flint.

William Lindsay Alexander was born at Leith on 24th August 1808. He was educated at the High School of his native town and in the Universities of Edinburgh and St Andrews. He distinguished himself in all his classes, but especially in those of Latin, Greek, Logic, and Moral Philosophy. While at St Andrews his earlier religious impressions were much deepened by intercourse with a pious fellow-student, and through the inspiring influence of Dr Chalmers. Although he began preaching when still a student of Arts, it was not until 1832, five years after he had left college, that he made choice of the Christian ministry as his profession. Teaching, literature, law, medicine, all presented themselves to him with competing claims. During the greater portion of this period of indecision and unsettlement he was occupied as classical tutor in the Congregational Academy at Blackburn. Passing through Liverpool in 1832, he was persuaded to occupy for a Sunday the pulpit of Newington Street Independent Chapel, then vacant. The result was that he remained in charge of the congregation for a year and a half, putting his qualifications for the ministry to a thorough test, and gradually coming to feel that he had found his true vocation. He afterwards went to Germany, and studied theology for a short time in Halle and Leipsic.

On 5th February 1835 he was ordained to the ministry, and became the pastor of the congregation meeting in what was then called "North College Street Chapel," Edinburgh. The connection then formed lasted somewhat over forty-two years. Mr Alexander at once gained, and to the last retained, great popularity as a preacher. In stimulating and guiding the Christian energies of his congregation he was also eminently successful. Gradually he attained in his own denomination an influence with which that of no one else in Scotland could be compared, while his services to the common Christian cause, his genuine catholicity of spirit, and his candour and courtesy even as a controversialist, made his name honoured in all denominations. His scholarship, literary talents, and theological acquirements became attested by writings which spread his reputation far beyond the limits of Britain. Notwithstanding a certain shyness and reserve of manner, his amiability and affectionateness of nature attracted to him numerous warmly attached friends. Among the events and dates of his life during his ministry in Edinburgh, these may be specified,—his marriage in August 1837; his delivery of the Congregational Lecture at London in 1840; his editorship of the *Congregational Magazine* from 1836 to 1840; his receiving of the degree of Doctor of Divinity from the University of St Andrews in 1845; his candidature for the chair of Moral Philosophy in the University of Edinburgh in 1852; his appointment to the Professorship of Theology in the Congregational College in 1854; his removal with his people from Argyle Square to Queen Street Hall in 1855, and thence to the new church (St Augustine Church) on George the Fourth Bridge in 1861; his election as examiner in philosophy at St Andrews University in 1861; his visit to Palestine in 1869; his selection as a member of the Old Testament Revision Company in 1870; his appointment by the Council of Edinburgh University assessor to the University Court in 1871, and reappointment in 1875; and "the greatest sorrow of his life," the death of Mrs Alexander in the last-named year. He published *The Connection and Harmony of the Old and New*

Testaments in 1841; *Anglo-Catholicism not Apostolic* in 1843; *Switzerland and the Swiss Churches* in 1846; *Christ and Christianity* in 1854; *The Life and Correspondence of Ralph Wardlaw, D.D.*, in 1856; *Christian Thought and Work* in 1862; and *St Paul at Athens* in 1865. He contributed to the eighth edition of the *Encyclopædia Britannica* three elaborate treatises—*Moral Philosophy* (vol. xv., 1858), *Holy Scriptures* (vol. xix., 1859), and *Theology* (vol. xxi., 1860). From 1861 to 1869 he superintended the publication of the third edition of Kitto's *Cyclopædia of Biblical Literature*, and supplied a very large number of the articles which appeared in it. He was also the author of at least forty sermons, lectures, or pamphlets, published separately, and a frequent contributor to Reviews and Magazines.

Dr Alexander resigned his ministerial charge on 6th June 1877, and was in the same year appointed Principal of the Theological Hall, while retaining his professorship. From a sense of growing infirmity, these latter offices also he resigned in 1881. In 1884 he received the degree of LL.D. from the University of Edinburgh, on the occasion of its Tercentenary. Amidst deep and wide regret, on the 20th December of that year, he died at Pinkieburn, leaving behind him many a good work to perpetuate and endear his memory, and the example of an unsullied and beneficent, faithful, and consistent life.

Dr Alexander was elected a Fellow of the Royal Society on 29th April 1867, one of the vice-presidents on 24th November 1873, and was re-elected a vice-president on 22nd November 1880. He wrote a number of obituary notices of eminent members, and delivered the Opening Address of the Session 1876–77.

Having indicated the chief facts of his life, let us now glance at the chief aspects of his character.

It was impossible to think of him otherwise than as a remarkably accomplished scholar. He was throughout his life an earnest student. No one knew better that knowledge is not the supreme object of human life, yet no one could realise more how precious and pleasant it is, and how closely connected with what is best. Hence a large portion of his daily life was given to its acquisition, and not selfishly, but in the belief that through self-improvement he would the more profit others. He had a keen interest in most kinds of science and learning; had cultivated with special care various departments of theology and philosophy; was intimately conversant with Biblical studies; was widely read in classical and modern literature; and was an excellent Latinist, Hellenist, and Hebraist. His mastery over the classical tongues as poetical media is amply attested by the collection of Greek and Latin verses which he printed privately and dedicated to his brethren of the Hellenic Society. His attainments as a Hebraist he had many opportunities of applying. He delighted in good English poetry, and was the author of a considerable number of very meritorious English hymns.

The amount of literary work which Dr Alexander performed must be regarded as marvellous, when it is considered with what diligence and success he discharged the many duties of his ministry and professorship. Yet none of his writings bear the marks of hasty and inadequate preparation. The briefest articles from his pen in *Kitto* are carefully executed. That he achieved so much as an author was doubtless due largely to strength and readiness of memory, clearness and vigour of thought, and facility of accurate and appropriate expression, but it was due as largely to his self-denying and methodical employment of his time. In this respect few can ever have surpassed him. At the commencement of his ministry he formed the resolution never to have what people called "a spare hour," but to lay out his work every day so as to know each hour exactly what to do; and to this resolution he steadily adhered to the close of his life.

From the time that he listened to Chalmers in St Andrews, philosophy, and especially moral philosophy, had strong attractions for him. How high was his estimate of philosophy and his ideal of the philosopher may be best learned from his eloquent and elaborate address to the Philosophical Society of the University of Edinburgh on his election as president in 1875. The most adequate measure of his philosophical ability is, however, the treatise on Moral Philosophy in the *Encyclopædia Britannica*. It presents us with a clearly defined, well-arranged, skilfully rounded system of ethical science. If not exhibiting much originality, it displays extensive learning and careful and independent reflection. It fully entitles its author to an honourable place among Scottish moral philosophers.

Dr Alexander devoted, of course, far more of his time and energy to theology than to philosophy. And it may safely be said that among his contemporaries in Scotland there was no more generally accomplished a theologian, although he was doubtless surpassed by several of them in particular qualities. He attained a high reach of excellence alike in exegetical, historical, apologetic, systematic, and practical theology. In all these departments he produced excellent works. On any special theological problem he could at once bring to bear ample knowledge and a rich combination of strong and disciplined mental powers. It cannot, indeed, be said that in theology, any more than in philosophy, he opened up or even followed out new paths of research. His mind rapidly reached maturity, and the religious opinions which he formed in youth remained almost unmodified to the close of his life. Within the limits of so-called orthodoxy, however, his intellect acted with admirable freedom and effectiveness. He held firmly to the Calvinistic system of doctrine and to the Congregational scheme of Church government, but with conspicuous independence of judgment. On various theological and ecclesiastical questions he differed decidedly even from those with whom he was in the main most in agreement. This appears very clearly in his Memoirs of Dr Wardlaw, in which criticism mingles so largely with admiration.

Dr Alexander took a somewhat prominent part in most of the religious controversies of his time. On the platform and through the press he felt called to set forth his views on Episcopacy, Anglo-Catholicism, Romanism, Church Establishments, and the like; he was drawn into the Voluntary, Spiritual Independence, Morrisonian, and some minor conflicts. It will be admitted by all, however, that while he always fought with vigour, he also always fought without bitterness or unfairness, and obviously from no love of strife itself or desire for personal or party victory, but from a sense of what he felt due to truth and the public good. As was to have been expected in the case of one whose mind was so justly balanced and so catholic in its sympathies, the more experience he acquired of religious controversy the more disappointed he became with its results, and in his later life he kept aloof from it.

As a pulpit orator he was of remarkable merit. Never aiming at popularity, making it a rule not to prepare so-called "great sermons," constantly dealing largely in the exposition of Scripture and the setting forth of doctrine, habitually keeping feeling under restraint, and very sparing of gesture and action, he was yet not only a most instructive, but a most interesting and impressive preacher. His tall stature and noble presence, his admirable delivery, his style refined yet strong, somewhat elaborate but also singularly lucid, the amount of knowledge which he communicated, and of light which he cast on Scripture, his intellectual force, his vivid and deep realisation of spiritual things, and the judiciousness and pointedness of his practical applications of truth, combined to make him a great and beneficent power in the pulpit.

As a man his character commanded universal respect. None doubted his piety and benevolence any more than his learning or ability. He gained many friends, and alienated none. He was especially at home in scholarly and intellectual society, and where at home he was a charming companion, unaffected and genial, with a keen sense of humour and hearty love of mirth, and with an inexhaustible store of anecdotes, which he delighted to tell, and which he told exceedingly well.

His private and domestic life has been gracefully delineated by Miss E. T. M'Laren, in reminiscences originally printed for private circulation, but now incorporated in the Life of Dr Alexander by the Rev. Mr Ross. Mr Ross himself, as an old student of Dr Alexander, has given us an account of his character and work as a professor, from which it is apparent that he was nowhere more admirable and successful than in his class-room.

The memory of Dr William Lindsay Alexander will be long affectionately cherished and highly honoured.

WILLIAM CHAMBERS, LL.D. By David Patrick, M.A.

William Chambers, one of the founders of the publishing firm of William and Robert Chambers, and in his later years distinguished for his public spirit as a citizen, was born at Peebles on the 16th April 1800, his father being a cotton manufacturer there. William, the eldest son, received a fair elementary education at Peebles; but as, owing to the father's misfortune, his school days terminated with his thirteenth year, his education for life-work was mainly due to the habit, very early acquired and long maintained, of miscellaneous and extensive reading. The household migrated to Edinburgh in 1813, and next year William was apprenticed to a bookseller. Immediately after his five years' apprenticeship was out, he began business in a very humble way for himself, and soon added to bookselling the occupation of a jobbing-printer. He by-and-by ventured to print and publish small pamphlets written or compiled by himself or his younger brother Robert, also established as a bookseller in Edinburgh. Through much industry, care, and economy they each prospered, and by 1825 what they called their "dark ages" had closed for ever. In 1825 William produced *The Book of Scotland*, and had a share with his brother in compiling a gazetteer; but it was the *Chambers's Edinburgh Journal*, projected and started by William in 1832, that brought great and permanent success to both brothers. From the beginning, Robert was the most important contributor to the Journal; and a month or two after it was fairly afloat, the two brothers united their resources and enterprise under the now so well known firm of W. & R. Chambers. Other important publications of the firm were the *Information for the People* (1833); the *Educational Course*, comprising an extensive series of text-books in history, science, and literature; the *Miscellany*; the *Encyclopædia* (10 vols., 1859–1868); the *Cyclopædia of Literature*, and numerous works by Robert Chambers. In 1859 the elder brother presented his native town with a public library, reading room, and museum. In 1865 he was chosen Lord Provost of the city of Edinburgh, and in this capacity carried out a very important measure for the improvement of the city, by substituting healthy houses and airy streets for lanes and closes of pestiferous hovels. He was the chief promoter of a partial restoration of the ancient Kirk of St Giles; and in 1878–83 he carried out a more complete and extensive restoration at his own expense. He found time to write an admirable county history of Peeblesshire (1864), a short history of France, sketches of tours in Holland, America, Italy, and France, various other short works, and a memoir (with autobiographical reminiscences) of his brother Robert, who was a member of this Society from 1840 till his death 1871, and is known as the author of numerous works, including the *Traditions of Edinburgh*, the *History of the Rebellion*, the *Ancient Sea Margins*, and the (anonymously published) *Vestiges of Creation*. William became a fellow of the Royal Society of Edinburgh in 1860; and he was made LL.D. by Edinburgh University in 1872. For his services to the cause of public instruction, and his work as a civic ruler, an offer of knighthood, which he declined, was made in 1881. But when, a fortnight before his death, a baronetcy was offered him, he accepted it. It had not, however, been formally conferred or gazetted, when on the 20th May 1883 he died, at the advanced age of more than 83 years, and but a few days before the ceremony that marked the completion of the last work of his life, the reopening of the restored church of St Giles. He was buried in the place of his birth, and many manifestations were made of esteem and gratitude for his services to English-speaking men and women, by providing works of instruction and entertainment accessible at small cost to all of whatever rank or condition. His life of unremitting labour and his remarkable business abilities brought to him wealth, honour, and influence, and these were by him faithfully turned to account for the general good.

DAVID STEVENSON.

David Stevenson, the third son of the late Mr Robert Stevenson, the well-known civil engineer, was born at Edinburgh on the 11th January 1815. Educated at the High School and University of Edinburgh, he elected from the first to follow his father's profession. Before entering on his apprenticeship he was for some time in the workshops of one of the best millwrights of the day, where he acquired manipulative skill and the proper methods of working in different materials,—a course he always advocated for those who intended to follow the profession of civil engineering. After serving a regular pupilage under his father, during which period he had ample opportunities of attending various engineering works in progress, he was for some time engaged with Mr Mackenzie on railway works, particularly the Edgehill Tunnel and the Liverpool and Manchester Railway. He gave a description of the "Liverpool and Manchester Railway" to the Royal Scottish Society of Arts in February 1835, and was awarded their medal for his exposition. This paper was followed, in March 1836, by "Remarks on the Dublin and Kingston Railway." In 1835 Brunel asked Mr Stevenson to join his staff at the Thames Tunnel works,—an offer which he could not accept, as he had been appointed to superintend the construction of other works.

During the summer of the year 1837, Mr Stevenson made a tour in Canada and the United States, and the result of his inspection of the engineering works of these countries was given in a volume, published in 1838, entitled "Sketch of the Civil Engineering of North America," which was republished with additions in 1859, as one of Weale's series of engineering works. The engineering practice therein described was peculiarly applicable to newly developed countries, where timber forms the chief material employed. The views expressed and the drawings given in this book, with reference to the fine lines and speed of American river and lake steamers, were received in this country by shipbuilders with distrust, if not ridicule; but the bluff bows of British sea-going and river steamers, and short-stroke engines, all below deck, gave way to finer lines and engines of high power and long stroke; and soon thereafter steamships were plying on the Clyde at higher speed than in America. He had models made in New York of two of the fastest steamers,—a sea and river boat,—which were submitted to the Admiralty after his book was published; but as the "lines" had been there given, the authorities did not care for the models, and they ultimately went to the Russian Government. In this book Mr Stevenson also pointed out the true conditions under which waves are formed, which his subsequent experience as a marine engineer amply corroborated.

Mr Stevenson entered into partnership with his father and brother Alan in 1838. As his father was then nearly 67 years of age, and his brother was wholly engaged with the arduous works at Skerryvore Lighthouse, the entire management of the business fell upon Mr Stevenson, and very soon his advice was much sought in reference to the improvement of rivers and harbours, and the construction of docks and other marine works. There are, indeed, very few rivers and harbours in Scotland with which he was not in some way professionally connected. He was also called upon to report or to execute works for the improvement of the rivers Dee, Lune, Ribble, and Wear in England; the Erne and Foyle in Ireland; and the Forth, Tay, Ness, Nith, and Clyde in Scotland. He designed and executed the works of restoration and enlargement of the Fossdyke in Lincolnshire,—the oldest artificial navigation in Britain,—the widening and deepening being accomplished without stopping the traffic. His advice was also taken on many important questions relating to salmon fishings in rivers and estuaries, and in his Report of August 1842 on the Dornoch Fishings, he defined the different compartments of rivers, according to their physical characteristics, as "sea proper," "tidal," and "river proper." The views expressed in this report were subsequently treated at greater length in "Remarks on the Improvement of Tidal Rivers," communicated to this Society on 17th March 1845, which paper was afterwards published in a separate form by Mr Weale. In this paper he stated his views with regard to the special works which should be undertaken for the improvement of the different compartments, and he showed conclusively that, if tidal propagation were accelerated, difference of level or height of head will be lessened and the velocity of the tide currents decreased; and the notion that, by deepening a river and removing obstructions, the water in it may be caused to rise higher and to endanger property on its banks, was without foundation. All his subsequent experience went to prove that the views expressed more than forty years ago were sound. He was also the first to enunciate the true theory of the origin of bars at the mouths of rivers, and to point out the works necessary for removing them and preventing their reformation. The necessity of having accurate data before designing works for the improvement of rivers, estuaries, and harbours led to his writing a treatise on the "Application of Marine Surveying and Hydrometry to the Practice of Civil Engineering." His known standing as a marine engineer led his old friend, the late Mr Adam Black, to invite him to write the article "Inland Navigation" for the last edition of the *Encyclopædia Britannica.* This article was republished in 1858 as a separate treatise, entitled "Canal and

River Engineering," and it is now in its third edition. In this book he has given the results of his practice in the treatment of rivers, and it will long remain the standard work in this difficult branch of engineering. In 1877, at the request of the authorities, he delivered a course of four lectures on "Canal and River Engineering" to the students of the School of Military Engineering, Chatham.

During the height of the railway mania, when speculators were overwhelming the Admiralty and Woods and Forests with schemes too numerous to be dealt with by the officials, Mr Stevenson was appointed to hold Courts of Inquiry, under the "Preliminary Inquiries Act," into the merits of a large number of railway and harbour projects and water-supply schemes, and in all cases save one his views were given effect to by the Authorities and Committees of Parliament. This exception was the proposed crossing of the Clyde by the Caledonian Railway. He reported that the railway might be allowed to cross the Clyde above Stockwell Bridge, but the Admiralty refused their sanction. A crossing, however, was subsequently applied for, and has been made.

In 1853 Mr Stevenson succeeded his brother Alan as engineer to the Northern Lighthouse Board, and, along with his brother Thomas, who was at a subsequent date conjoined with him in the engineership, he designed and executed no fewer than twenty-eight beacons and thirty lighthouses, three of which—on North Unst, Dhu Heartach, and the Chickens Rocks—were works of great difficulty, requiring the exercise of great engineering skill. The advice of the firm was also taken by the Governments of India, Newfoundland, New Zealand, and Japan on lighthouse matters, and schemes for the lighting of the whole coasts of the two last countries were matured, and are now being carried out. In connection with the lighting of the coasts of Japan, where earthquakes are of frequent occurrence, Mr Stevenson devised the aseismatic arrangement, to mitigate the effect of shocks on the somewhat delicate apparatus used in lighthouses, and was awarded the Makdougall-Brisbane Medal of the Royal Scottish Society of Arts for his invention. Mr Stevenson took a great interest in the introduction of paraffin as an illuminant for lighthouses, instead of the more expensive colza oil. After experiments conducted at Edinburgh with the Doty burners, and actual trial during a month at Girdleness Lighthouse, a report was made to the Northern Lighthouse Board, embodying the following results:—That paraffin, as now manufactured, with a high specific gravity and flashing point, is safe; that the flame is of great purity and intensity, and easily maintained; the lamp glasses and lamps used for colza are equally suitable for paraffin; and that the initial power of the lights on the Scottish coasts would be exalted, and this, too, at an annual saving of £3500. The relative merits of colza oil and paraffin were thus settled, and most British and many European, foreign, and colonial lighthouses now consume paraffin, with an increased luminous intensity, and decreased cost of maintenance.

Mr Stevenson frequently appeared before Parliamentary Committees, and also gave evidence before Special Committees and Royal Commissions on Harbours, River Improvements, Harbours of Refuge and Lighthouses. For these Committees and Commissions he always prepared with scrupulous care; and he was a most conscientious witness, never entering the box without being satisfied as to the soundness of the cause he was supporting; and in no case did a Committee ever throw out a Bill, the Parliamentary plans and estimates of which he had prepared. In his native city Mr Stevenson was greatly respected, and his advice on many important matters connected with city improvements was sought and highly valued. His views on the city improvement scheme, as conveyed to Lord Provost Chambers and the late Mr David Cousin, city architect, along with his letters which appeared in the *Scotsman* at the time, greatly facilitated the initiation of this great sanitary improvement, now nearing its completion. Among other local works, his firm designed and carried out the Edinburgh and Leith and North Leith sewerage schemes, and the widening of the North Bridge.

Mr Stevenson was consulting engineer to the Convention of Royal Burghs of Scotland and to the Highland and Agricultural Society. In the affairs of the latter he took a lively interest, especially in the trials of improved agricultural implements; and he contributed several papers and reports to their *Transactions*, notably one on the reclamation of land, and one on the relative merits of different systems of steam ploughing. The paper on "Reclamation and Protection of Agricultural Land" was republished as a separate treatise in 1874.

Mr Stevenson's books have taken a permanent place in engineering literature. Amid the exacting calls of his profession he found time to write many papers on engineering and cognate subjects, in addition to the books already noticed. He also wrote several articles for the last and the present editions of the *Encyclopædia Britannica*, among which may be noticed "Canal," "Cofferdam," "Diving," and "Dredging." He was also the author of *Our Lighthouses*, being two articles written for his old friend, Dr Norman Macleod, while editor of *Good Words*, subsequently republished by Messrs Black, and of the *Life of Robert Stevenson*, published in 1878.

Mr Stevenson was twice elected President of the Royal Scottish Society of Arts, and for his Presidential Address of 1869 he chose as his subject "Altered Relations of British and Foreign Industries and Manufactures," in which he strongly urged the propriety of artisans improving their manipulative skill and their knowledge and management of the materials with which they had to deal, if they did not wish to be distanced in the race by foreign competition. He was elected a Fellow of this Society in 1844, and subsequently acted as a member of Council and one of its Vice-Presidents. In addition to the "Remarks on the Improvement of Tidal Rivers" already noticed, and several obituary notices of professional brethren, he contributed to our *Proceedings* "Notices of the Works designed by Sir C. A. Hartley for the Improvement of the Danube," "Notices of the Ravages of the *Limnoria Terebrans* on Creosoted Timber, and on Greenheart Timber." "Notice of Two Earthquakes on the West Coast of Scotland," and "Notice of Striated Rock Surfaces on North Berwick Law." He was elected a Member of the Institution of Civil Engineers in 1844, and acted as a member of its Council from 1877 till 1883, when he retired on account of ill-health; he was also a member of the Société des Ingénieurs Civils, Paris, and of other learned Societies.

Mr Stevenson took a warm interest in the better endowment of the Chairs of the University of Edinburgh, and was mainly instrumental in founding the Glover Divinity Fellowship. He was a great lover of art in all its branches, and had formed a somewhat valuable collection of etchings and engravings, begun when a boy at the High School, his school companion in print-hunting being a life-long friend, Sir Theodore Martin. He was a man of sound judgment, unswerving rectitude, utterly devoid of ostentation, kind, open, and easily accessible. He was practically laid aside from work for about two years, and he died at North Berwick, on the 17th July 1886, in the seventy-second year of his age.

BISHOP COTTERILL. By Dr Cazenove.

Henry Cotterill was born in the year 1812, on the 6th day of January, a day ecclesiastically known as the Feast of the Epiphany, and in popular parlance as Twelfth Night. He was the son of the Rev. Joseph Cotterill, rector of Blakeney, in the county of Norfolk. Mr Cotterill had been educated at Cambridge, and had taken a high degree, coming out as Seventh Wrangler. The grandfather of the future Bishop had also been a Cantabrigian, and was known in Sheffield as a man of culture. He was the author of a book of family prayers. All three were successively members of the same College. All three could say, with the poet Wordsworth,

> "The Evangelist St John my patron was,"

and all could, with him, avow a fondness for mathematical as well as for classical studies.

In classics Henry Cotterill found a preceptress in his mother. This lady, known before her marriage as Miss Anne Boak, was very clever and clear-headed. She was a great friend of the celebrated Hannah More, and to some extent assisted that lady in the preparation of a tale, which was widely read at the time of its publication, *Cœlebs in Search of a Wife.* Miss Boak contributed some chapters which contained descriptions of scenery. She had also a considerable acquaintance with mathematics, and was generally a learned woman.

Not only did she superintend the education of her three daughters, but she instructed her two sons, Henry and George Cotterill, in Latin, until they were fifteen years of age.

Here, it will be said, is a clear case of heredity. I am far from wishing to dispute the point; but we must not, I think, neglect another element of the case. A distinguished scholar and mathematician, who had been well acquainted with a school which was attended by boys from homes of very varied station and character, told me that, as a rule, the difference was immense between the progress of the pupils who went back daily, or at set periods, to homes where they heard nothing connected with their studies, and those who, when not at school, lived in the houses of relatives or of friends, which were the abodes of educated people. Extraordinary genius will no doubt triumph over these and many other obstacles. But to the youthful student the lack of sympathy at home is a formidable disadvantage. Oliver Wendell Holmes implies, I think, that it has been found so in the United States of America, as well as in Europe. And the inquirers into the influence of heredity ought, it seems to me, to take some pains in examining into this phase of the question, and ask whether this and that man of mark did or did not in youth enjoy the benefit of an atmosphere of culture.

Whatever be the decision, it is at least clear that Henry Cotterill was in this respect exceptionally favoured. He began to receive lessons in Latin when he was five years old; and at the age of fifteen he and his brother George were, as a favour, accepted as private pupils at Cambridge, by Mr Scholefield, subsequently so celebrated as the Regius Professor of Greek in the University of Cambridge. From this admirable teacher Henry Cotterill learnt his first lessons in Greek, and to his latest day he always expressed his deep gratitude to his tutor, and his keen sense of the good fortune he had enjoyed in having had such a preceptor. Nor was he less favoured in mathematics. A very eminent mathematician, William Hopkins (father of a philanthropic lady, Miss Ellice Hopkins, subsequently a great friend of the Bishop's), took charge of his studies in *Mathesis.*

At a later date, a brilliant Cambridge scholar described, in beautiful Greek Iambics, how Jupiter, being angry with mortals, commissioned Vulcan to invent a new plague, and how from this command came forth the penal infliction of mathematical study. Such was not, as has already been observed, the sentiment cherished towards the science of lines and of numbers by this youthful classic. Contrariwise, his proficiency in this new field of learning seems to have even surpassed that which he achieved in ancient languages. And during vacations he was sure of living in an atmosphere where his studies would receive abundance of encouragement and sympathy. His sisters were ladies of cultivated taste, the youngest especially being a good Latin scholar.

At Cambridge he found friends among contemporaries, and also some among seniors, who, in different ways, influenced his career. Among the seniors, besides the tutors already named, he was acquainted with Professor Sedgwick, with Professor Airy (afterwards the Astronomer Royal), and the aged Mr Simeon. Among those of his own standing may be named Mr Dickinson, afterwards representative in Parliament for Somersetshire; and a member of a highly gifted family, a Merivale, brother of a distinguished Oxonian, W. Herman Merivale, and of equally eminent Cantabrigians, such as the present Dean of Ely. But specially intimate was he with a son of the Right Hon. Henry Goulburn, sometime Chancellor of the Exchequer. In both classics and mathematics these two, Goulburn and Cotterill, were keen, but most friendly rivals. We cannot doubt but that from such guides and friends, and from several more like them, Henry Cotterill must have learned a great deal, though the intercourse cannot possibly have been a merely one-sided bargain. Some of them, as Merivale and Goulburn, were not permitted to display all their powers, having died at a comparatively early age.

In 1832, a year known in British history as that of the passing of the Reform Bill, Henry Cotterill was elected a scholar of St John's College, Cambridge. In that same year he won the University Bell Scholarship, one of the blue ribands of undergraduate life, as an evidence of proficiency in classics; though its glories are perhaps slightly limited by its being confined to the sons of clergymen.

In 1835 he took his Bachelor's degree, his work at Cambridge culminating in the extraordinary success of his being Senior Wrangler, First Smith's Prizeman, and ninth in the First Class of the Classical Tripos, which was headed by the Second Wrangler, his young friend Henry Goulburn. This achievement probably justifies the remark of the late Principal of the University of Edinburgh, Sir Alexander Grant, that Henry Cotterill left Cambridge bearing a greater weight of honours than any other student had gained.

Among the few rivals who have nearly approximated, may be named Charles Webb Le Bas, afterwards Principal of Haileybury College, and the Hon. William Cavendish, now Duke of Devonshire. Almost as a matter of course, Mr Cotterill was, soon after taking his degree, elected a Fellow of St John's.

The present imperfect sketch is mainly concerned with the career of its subject in relation to those gifts which would be felt to constitute his claim to become a Fellow of this Royal Society. But it is impossible to pass by in silence certain elements of the case which exercised a very real, though in part an indirect, influence upon his mental development.

At this juncture he might have laid out for himself a course of life which would necessitate his remaining a man of study rather than of action; or he might have chosen a profession, such as that of the bar, in which it would be possible, while relegating to a secondary position his Cambridge studies, to make use of the mental training thus acquired. His University had abundant examples to encourage him in either of these directions,—brilliant honour-men who had become famous as scholars or men of science, and others who had been conspicuous as barristers and as judges.

But the tone of another profession ruled in the home in which he had been brought up, even more strongly than the love of culture for its own sake, or for the prizes which might thereby be won. Entirely by his own choice,—though no doubt it was a choice greatly moulded by the influences around him,—Henry Cotterill resolved to take Holy Orders. But this was not all. His father had begun to cherish, in his maturer years, a keen sympathy with missionary work. It came seemingly too late in life for him to change his sphere of labour. But he had expressed a hope that his sons, even if they did not feel called to devote their lives to direct missionary work, might at least for a time occupy positions in which they could support and assist missionary efforts. The father's wish was never forgotten by the son, who always regarded it as a grave mistake to send out to our Colonies only clergy of powers below the average.

Henry Cotterill was ordained deacon in 1835, and priest in the year following. In this latter year a presentation to one of the East India Company's chaplaincies was placed in the gift of the

University of Cambridge. Much to the surprise of many friends and of still more numerous bystanders, Mr Cotterill accepted the nomination. That such a step was not calculated to lead to preferment at home was obvious enough; but the father entirely sanctioned the proceeding; and the son never, I believe, for a moment regretted it.

The appointment took him to the Madras Presidency. Before leaving England he vacated his fellowship by marriage with Anna, daughter of John Panther, Esq. of Bellevue, in Jamaica. By this honoured and much-respected lady, who lives to mourn his loss, he became the father of four sons and two daughters, of whom all, but one daughter, have survived him.

At Madras he saw much of missionary work among the heathen, and acquired an interest in it which never left him. But the climate did not suit him, and at the end of eight years' residence his health was seriously affected. In 1847 he returned to England, and accepted the position of Vice-Principal of Brighton College, a newly founded institution. In 1851 he succeeded to the Principalship, rendered vacant by the death of its previous occupant, Dr Maclean.

Although this College prospered greatly under his care, there were those among his friends who felt that it was not a sphere that afforded full scope for his varied powers. One of these, a layman, a member of a family deeply interested in missions, walking in London, is said to have noticed an advertising board headed by the words "Wasted Steam." The title suggested to this gentleman's mind instances of such loss among men whom he had known, and it struck him that Henry Cotterill was at that moment an example of such waste. "By the way," so his thoughts ran onward, "Archbishop Sumner told me that the See of Grahamstown had become vacant by the decease of Bishop Armstrong, and that a successor was being sought for it. Mr Cotterill would be the very man for the place." Fired by this idea, he at once proceeded to Lambeth, and the result was that on November 23rd, 1856, Henry Cotterill was consecrated and then duly gazetted as Lord Bishop of Grahamstown.

The Bishop of Capetown, Dr Gray, seems at first to have feared that he and his new colleague might not work harmoniously. An unlooked-for event brought them into thorough concord with each other. In the year 1836, that is to say the year after that of Mr Cotterill's Senior Wranglership, the place of Second Wrang. had been won by a member of St John's, who was thereupon elected Fellow of that College. His name was Colenso; and after having had experience, both in tuition as a mathematical master at Harrow, and also in pastoral work as a country vicar, he had been selected for the office of Bishop of Natal. Dr Colenso published works certainly of a startling character; and his former brother-fellow, the Bishop of Grahamstown, in November 1863, formed part of an Episcopal Court which condemned the teaching of Bishop Colenso as heretical. This sentence was not confirmed by the State, inasmuch as the Privy Council declined to recognise the legal validity of the letters-patent granted to Bishop Gray, and of his claims to act as Metropolitan. The opinion, however, delivered by Bishop Cotterill was allowed on all sides to be one of remarkable clearness and ability.

In 1867 the Archbishop of Canterbury, Dr Longley, held a gathering at Lambeth of the Bishops of the Anglican Communion; and a similar one took place in 1878, under the presidency of Archbishop Tait. On both occasions Bishop Cotterill was chosen to act, in company with an English prelate, as a general secretary; and also as sole secretary to a committee appointed to consider the constitution of the Colonial daughters of the Anglican Church, and their relations to the mother Church of England. In these situations he enjoyed an opportunity of showing to those around him his capacity for business, his judicial temper, and his largeness of view. These qualities made a special impression upon some of the Bishops who had come from Scotland and from America.

The acquaintance with his powers thus obtained greatly influenced the clerical and lay electors of the Episcopal Church in the diocese of Edinburgh, when in 1871 they were seeking for a coadjutor to Bishop Terrot. Other candidates withdrew, and on April 26th the Bishop of Grahamstown was elected by the vote of both the clerical and lay chambers, *nemine contradicente*, to the office of coadjutor Bishop. Bishop Terrot only survived this event by about eleven months; and as Dr Cotterill had been chosen *cum jure successionis*, he became full Bishop in April 1872.

With the details of his rule we are not here concerned: and it must suffice to say, that he proved himself to be active, energetic, tolerant, and accessible. If, as seems possible, these qualities were more quickly recognised by the clergy than by the laity of his communion, this may have arisen from the fact that the former, being brought into more immediate contact, saw most of him, and that his good gifts were of a character that required such intercourse to bring them out in all their fulness.

He was greatly interested in the proceedings of this Royal Society of Edinburgh, of which he was elected a Fellow soon after his arrival in Scotland. He was chosen a member of the Council, and subsequently one of the Vice-Presidents. If he did not contribute any papers, such as the valuable ones supplied by his predecessor, Bishop Terrot, it must be remembered that the clerical duties of the occupant of his post had been largely increased. Most especially during eight years (1871–1879) his mind was occupied with the erection and organisation of the Cathedral, which sprung from the munificent bequest of Barbara and Mary Walker. In this complicated task he was held to have been eminently successful. It is perhaps permissible to remark that, in his association with the *savans* of this Society and of the University he expressed himself as greatly gratified with the large amount of ability among the votaries of physical science, which was ranged upon the side of belief, in that great contest with unbelief, which Goethe in well-known words has declared to be "the proper, peculiar, and deepest theme of universal and human history."

It remains to say something concerning the indirect and the direct influence of his academical studies upon his professional life. Indirectly it taught him, as it has taught so many academical students, not to be satisfied with mere surface work in any department of study. Two illustrations, out of several that might be adduced, will serve to illustrate my meaning.

At Madras, during the tenure of his East Indian chaplaincy, he was brought into controversy with some of our Roman Catholic fellow-Christians. Not content to take the account of their tenets from hearsay and popular estimate, he made a serious study of the works of a famous champion of Roman theology, Cardinal Bellarmine; and to the close of his life he was able to cite concessions or ingenious replies, which he had met with in the pages of that eminent controversialist. He had been brought up, and always remained, a devoted son of the Reformation. But he was not averse to the study of the schoolmen, especially Aquinas; and he recognised, not wholly without admiration, in the theology which he so firmly opposed, a system which, in his own words, "touched the human mind at a great many points."

Again, in South Africa he found a system of law very different from that to which he had been accustomed in England. Dutch law, like Scottish law, is largely based upon that of ancient Rome. Straightway he became a student of Roman law. Whether the study of that or of any other system will render a mind judicial, if it is thoroughly imbued with the advocate-temper, may be doubted; but it can hardly be questioned that where its teaching falls on a congenial soil, it has a tendency to strengthen the upgrowth of a judicial harvest by reason of its general essence of admirable clearness and common sense. In 1878 some difficulties in the will of the Misses Walker were brought before the First Division of the Court of Session in Edinburgh. Bishop Cotterill's interpretation of certain clauses had been disputed by some of the Walker Trustees, including at least one eminent lawyer. The Court entirely confirmed the Bishop's view, and rejected that of his chief opponent.

As a scholar and a divine he was naturally much interested in the Revision of the New Testament. In the main he sympathised with the Revisers, and in general preached from their version. In the field of what may perhaps be called constructive theology his most important production was probably the volume entitled *The Genesis of the Church*, an original and thoughtful work, which may, though in a quiet and comparatively unnoticed manner, considerably influence the divinity of the future.

But as was to be expected from one who kept up his acquaintance with physical science, Bishop Cotterill was especially drawn towards the field of apologetic theology. Among contemporary writers none fixed his attention more than the late Dr Mozley, whom Sir James Paget—no mean judge—has called "perhaps the most philosophic divine of our age." *The Unseen Universe* at once arrested his notice, and in 1876 he contributed to the third number of the *Church Quarterly Review* a sympathetic and able criticism of this remarkable work. This was, I believe, his only contribution of any length to periodical literature. He was also, however, greatly struck by *Philosophic Doubts*, the work of a gentleman since known as the Right Hon. A. G. Balfour, successively Secretary of State for Scotland and for Ireland; all the more so in that he had prepared for the Victoria Institute a paper based upon a somewhat similar stratum of thought, entitled "The Relation between Science and Religion, through the principles of Unity, Order, and Causation."

This last-named paper was read in 1880. But it may be regarded as a continuation of a similar address delivered before the same Institute in 1878, "On the true Relation between Scientific Thought and Religious Belief;" which was followed by what many consider his happiest effort in this direction, namely, the small volume entitled *Does Science aid Faith?* published in 1882.

His acquaintance with colonial life not only led to his being on several occasions associated with English prelates in the choice of Anglican bishops for distant sees, but also induced him to deliver addresses bearing on the problems connected with modern civilisation. Among such papers may be named "Vital Christianity as affected by the present State of Science and Civilisation," read at Leeds during a Church Congress held there in 1873, and three lectures given at St Paul's Church, in York Place, Edinburgh, entitled "Progress." In compositions of this nature he not unfrequently avowed his obligations to several writers outside the ordinary range of theological study; such as, for instance, Fichte and Mr Herbert Spencer.

Very friendly relations, dating from the Lambeth Conference, existed between him and the Anglican prelates of the United States. He paid a visit to America, which he greatly enjoyed, in 1880; and was subsequently appointed Bedell Lecturer. These lectures, however, were read for him in 1884. Their subject was "Revealed Religion in Relation to the Moral Being of God."

There have been men of science who have combined with their gifts of knowledge that of a remarkable literary style. Such in France was the famous naturalist Buffon; and no one, whether ally or opponent, would deny this possession to Professor Huxley. It may be doubted whether, in the case of Bishop Cotterill, the gift of expression was quite on a par with the general level of his very high and varied endowments. It was probably, as a rule, happier in friendly conversational discussion than in set and formal efforts, whether spoken or written. With diffidence it may be suggested that the little volume already named, and the article in the *Church Quarterly Review*, are favourable examples of his style, when at its best.

He met the announcement that a fatal disease had seized him with singular calmness and Christian fortitude. His illness was cheered not only by the devoted assiduity of the partner of his life, and the other members of a most united family, but also by a sympathy which extended far beyond the limits of his own communion. He left the Church, over which he had presided, very grateful to him for his work, which had not only won the affection and respect of those worshipping in the Cathedral and other Episcopal churches, but had also tended to draw into closer communion two congregations which had previously been disunited. He was probably happier in a disestablished than he would have been in an Established Church, inasmuch as the conflicts in England between Church and State were to him a source of perplexity and regret.

He used to praise his contemporary, Archbishop Tait (in company with whom he had been consecrated Bishop), for never becoming too old to learn. It was an eulogy which might be fairly applied to himself. The condition of Scotland was in many respects very different from that of South Africa. He took pains to learn those differences. From his visit to America, from events of the day, from thinkers much younger than himself, if they were adepts in any special lines of thought or study, he was most willing to learn;* thus showing that he cherished in his inmost heart a deep humility, which chastened what might have been the temptation of his great acquirements and successes. Most prominently did this and other graces shine forth during the period of his latest illness in 1885.

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* The Rev. David Greig, M.A. of Aberdeen University, now Rector of Cottenham; and Dr Dowden, who has succeeded him in his Episcopate, may without invidiousness be named as illustrating this remark. The Bishop was also very sensible of the value of recent works of learned Presbyterian divines, such as those of Professors Flint and Milligan.

[*Note added December* 23, 1887.]

Since the above notice was written, Professor Tait has reminded me of the name of Dr Perry, late Bishop of Melbourne, as that of a Senior Wrangler, who, like Bishop Cotterill, had also taken a high place in the Classical Tripos; and my friend and relative, the Rev. Dr Luard, Registrary of the University of Cambridge, has, at my request, furnished me with a list of the most interesting examples of double honours taken at Cambridge between the years 1753 and 1854. I pass over those who did not win the highest place in one of the two departments (though it contains many names of students who rose to celebrity or high station in after life), and confine myself to a selection from the list of Senior Medallists, Senior Classics, or Senior Wranglers.

Among the Senior Medallists, who were also very high Wranglers, may be named Craven (afterwards Master of St John's), 1753; Halifax (Bishop of St Asaph), 1754; Law (Bishop of Elphin), 1766; Law (Bishop of Bath and Wells), 1781; (Archdeacon) Wrangham, 1790; Maltby (Bishop of Durham), 1792; Tindall (Chief Justice), 1799; Grant (Lord Glenelg), 1801; Parke (Lord Wensleydale), 1803; Blomfield (Bishop of London), 1808; Graham (Bishop of Chester), 1816; Hugh James Rose, 1817; Ollivant (Bishop of Llandaff), 1821.

Among the Senior Classics (some being also Senior Medallists) who were very high Wranglers, were (Professor) Selwyn, 1828; (Professor) Westcott, 1848; J. B. Lightfoot (Bishop of Durham), 1851.

Of the four Senior Wranglers, who have also been Senior Medallists, only two became subsequently eminent—Kaye (Bishop of Lincoln), 1804, and Alderson (Baron of the Exchequer), 1809.

The other Senior Wranglers who have been high in the Classical Tripos (since its institution in 1825) have been comparatively few; and Henry Cotterill appears to stand alone in combining with the Senior Wranglership, and a high place in the Classical Tripos, the position of First Smith's Prizeman.

William Denny, C.E. By John Henderson, Jun., F.R.S.E.

William Denny was born in Dumbarton on 25th May 1847. His education was commenced in the Academy of his native town. Shortly afterwards he was sent to Jersey, more particularly for the sake of his health, and after a residence of four years he returned to Scotland, and was placed in the Edinburgh High School, where he remained until he was seventeen years of age.

He had resolved to become a shipbuilder, and on leaving the High School in 1864 he entered his father's ship-yard in Dumbarton as an apprentice, and passed through the several departments, where he laid the groundwork of his future ability as a naval architect.

In 1868 Mr Denny became a partner in the firm of William Denny & Bros., and shortly after assumed the administrative charge of the extensive business conducted by the firm. He continued to occupy this position until his death on 17th March 1887.

He early showed great promise of becoming an eminent naval architect, and introduced a more scientific basis in all the practical work of shipbuilding. He wrote many papers, and took a prominent part in all discussions in connection with his profession.

Mr Denny had great force of character, and a wonderful gift of inspiring his staff, and those with whom he came in contact, with his own enthusiasm and earnest perseverance in carrying his investigations and experiments to a conclusion.

He was a fluent speaker, and his professional and other papers, which he read from time to time, were noted for the finished manner in which they were prepared and delivered.

He took a prominent part in the introduction of steel for shipbuilding, and did much to bring it into the general use it now obtains. He introduced an admirable system of conference between his firm and delegates from all trades represented in the works, in order to adjust and arrange all questions of wages, rules, &c., and these conferences were under his presidency during the last year of his life at home.

Such deep and active interest as he had in everything connected with the scientific part of his business would have absorbed all the energies of most men, but not so with William Denny. His nature was many-sided, and his sympathies were broad and deep. He was well read in many subjects, and proved himself a capable lecturer on art, politics, and many other subjects, in which he took a deep interest. Possessed of a warm and affectionate nature, he will be long remembered for the interest he took in every one with whom he came in contact, and the generous, but wise, assistance he was ever ready to afford in advancing the well-being of all who had the good fortune to know him.

Among the papers which he wrote were "The Worth of Wages"; "Dimensions of Sea-going Ships"; "On the Difficulties of Speed Calculations," for the latter paper he was awarded the Marine Engineering Medal of the Institution of Engineers and Shipbuilders in Scotland; "The Speed and Carrying of Screw Steamers," being the Watt Lecture delivered before the Philosophical Society of Greenock; "On the Question of Success"; "Christianity in this Life"; of the latter he was only spared to conclude the first part.

Mr Denny was appointed by the Government a member of the Load Line Committee, and he took an active part in all its investigations. He was a member of Council of the Institution of Naval Architects, a member of the Institution of Engineers and Shipbuilders in Scotland, of which he was president at the time of his death. He was also member of the Institution of Civil Engineers and of the Iron and Steel Institute. He was elected a Fellow of this Society on 3rd February 1879.

Dr DANIEL RUTHERFORD HALDANE. — From materials supplied by Dr John Smith, LL.D., and Dr Heron Watson.

Dr D. Rutherford Haldane was the son of James Alexander Haldane, who founded the Scottish Congregational body, and has sometimes been called the Whitefield of Scotland. He was of the family of the Haldanes of Gleneagles.

Our deceased Fellow was educated at the High School of Edinburgh, and during the six years of his attendance there his usual place in class was about third,—the dux for the first three years being "blind Laurie," and when that distinguished pupil left, the next dux was one who afterwards has done good work in another profession, the Rev. John M'Laren, D.D., minister of Larbert.

On leaving the High School, he studied at the University of this city until he obtained his medical degree. When he graduated as Doctor of Medicine, a gold medal was presented to him for his thesis on Diseases of the Liver.

He subsequently went abroad for the purpose of further study at the great medical schools of Vienna and Paris. He resided at the latter capital for eighteen months, and whilst there acquired a remarkable fluency in the French language, which he ever afterwards retained. On his return to Edinburgh he was appointed House Physician to the Infirmary, in which capacity he had acted prior to going abroad, and not long after this he was elected Physician to the Royal Public Dispensary and the New Town Dispensary. He subsequently became a Lecturer on Medical Jurisprudence, Pathologist to the Royal Infirmary, and Teacher of Pathology and Morbid Anatomy in the Extra-Mural School at Surgeons' Hall. On Dr Alexander Wood retiring from his Lectureship at the College of Surgeons, Dr Haldane began to lecture on the Practice of Physic in that institution, and at the same time he gave lectures on Clinical Medicine at the Infirmary. His classes were very popular with the students, as he had the reputation of being one of the best teachers in the Edinburgh School of Medicine. In 1876, about three hundred of his former pupils, among whom were many of our best known practitioners, presented him with an address in which his powers of accurate diagnosis, the clearness and grace of his style as a lecturer, and his vivid powers of description, were adverted to in terms of grateful appreciation.

In 1852 he was elected a Fellow of the Royal College of Physicians, and he afterwards held successively the offices of Secretary and President of that body. Whilst acting as Secretary to the College of Physicians, he took an important part in promoting the scheme under which the Royal Colleges of Physicians and Surgeons in Edinburgh, with the Faculty of Physicians and Surgeons of Glasgow, arranged to grant a conjoint examination and diploma to their students, known as the Double Qualification.

For his services in instituting this diploma, a handsome service of silver plate was presented to him. He was the representative of the College of Physicians at the General Council of Medical Education, and at the Infirmary Board. The General Council, Edinburgh University, elected him their assessor at the University Court.

He was also for several years medical officer of the Scottish Equitable Life Assurance Society. In acknowledging his services in this capacity, the Directors stated in their minutes—"that his perfect mastery of his profession, and the sound judgment which characterised his opinions were so conspicuous, that the Board placed the most perfect confidence in his advice, and are certain that it has been of the utmost value to the Society."

Dr Haldane chiefly devoted himself to the teaching and consulting departments of his profession. His contributions to the science of medicine were mainly of the nature of occasional practical papers, read before various professional bodies and associations, and constituted in not a few cases interesting additions to our knowledge of diseases of the heart, the nervous system, and alimentary canal. For a number of years he edited the *Edinburgh Medical Journal* with ability and success.

His life was destined to be cut short unexpectedly. On the Christmas day of 1886, when leaving his house, his foot slipped, and in falling he broke the lower part of his right leg. Complications, leading to a complete collapse of his system, followed on this injury, and he died on the 12th of April 1886.

The death of a physician so eminent and so widely known and appreciated, was the occasion of much regret both to the profession and the public of Edinburgh; and the more so as in private life he was distinguished by the gentleness and courtesy of his manners, his straightforwardness and high sense of honour. His funeral was attended by the Presidents and Fellows of the Royal Colleges of Physicians and Surgeons, and by a large assemblage of the general public. He was elected a Fellow of this Society in 1867.

JAMES PRINGLE.

James Pringle was born in Edinburgh in 1822. He was the son of Mr Murray Pringle, who for thirty years held the office of Secretary in the Adjutant-General's Office, and a similar position in the Naval and Military Academy, which long existed in the city. He received his education at the High School of Edinburgh, where he made great proficiency in the study of the classics, and stood third among his fellow-students in the list of honours during the last year of his educational course.

On leaving the High School he became a clerk to the Edinburgh Roperie Company. His business abilities and capacity for hard work led to his being promoted to the position of cashier in the Company's office, and on the occurrence of a vacancy in the management the entire responsibility of conducting the Company's business was devolved on him.

About six years ago, he began to take a prominent part in the public business of Leith, when he was returned as representative of the ratepayers to the Leith Dock Commission. Entering the Town Council of Leith in 1881, he was elected Provost of the burgh in November of that year, and continued to occupy the position till the time of his death. Like his predecessor in the civic chair, he was an ardent supporter of the Leith improvement scheme, and he was particularly active in obtaining a Provisional Order for the better preservation of Leith Links. He displayed great tact and energy, as well as unfailing courtesy, in the discharge of his onerous duties as chief Magistrate, and he took an active interest in all associations and movements for the amelioration of the condition of the poor, and the relief of suffering.

Mr Pringle also held the honourable office of Deputy-Lieutenant of the county. He found time to take an intelligent interest in the proceedings of the Geographical Society, and he was elected a Fellow of this Society on the 6th of April 1885. He died on the 11th of December 1886. His funeral, which was a public one, called forth an expression of general sympathy and regard, such as, perhaps, had never before been witnessed in the town over which he presided.

Dr Thomas Williamson.

Dr Williamson was born at Greenock in 1815, and claimed to be the last surviving representative of the ancient family of the Napiers of Kilmahew. When quite young, he was sent to study medicine at the University of Edinburgh, where he took his degree of M.D. at the age of twenty, in the same year becoming a licentiate of the Royal College of Surgeons, an institution of which he was elected a Fellow in 1857. He was one of the oldest members of the Medico-Chirurgical Society, and of the Royal Society of Edinburgh. In early life he held several public offices. He was for fully thirty years surgeon in Leith Hospital, and during the whole of his long residence in Leith took a warm interest in the welfare of that institution. At the time of his death he held the appointments of parochial medical officer and public vaccinator for the parish of South Leith, and medical officer of health for the entire burgh. The latter office obliged him to board vessels coming from ports where any epidemic was prevalent, and to his foresight is due the readiness in which Leith has been held, during the late visitations of cholera on the Continent, to deal with any emergency which might arise. His various public duties were performed with untiring vigilance and care, and he enjoyed the unqualified respect of his fellow citizens, among whom his long residence rendered his figure one of the most familiar in the community. Dr Williamson was an occasional contributor to medical journals on topics chiefly relating to sanitation. He published various pamphlets, and delivered several popular lectures on subjects relating to public health, and read a paper on the subject at one of the meetings of the Social Science Congress at Edinburgh, which was printed in their reports. On returning from Colinton, he was seized with an attack of apoplexy which terminated fatally on the 30th of December 1885. He was elected a Fellow of this Society on 7th December 1857.

John Milroy, Assoc. Inst. C.E.

The death has just been announced of Mr John Milroy, Assoc. Inst. C.E., one of the remaining links between the present and the great days of railway construction in which the late Mr Thomas

Brassey played a prominent part. Mr Milroy died at his residence, Torsonce House, Stow, near Edinburgh. For the past two years he had been in failing health, and ten days before his decease he was seized with a shock of paralysis, from the effects of which he never recovered. Mr Milroy was very early associated with Mr Brassey in railway work, so far back, indeed, as the year 1840, in the construction of the first line between Glasgow and Greenock, now belonging to the Caledonian Railway Company, and on which he was a sub-contractor. The most serious portion of that contract was the cutting of the well-known Bishopton Tunnel, which was carried almost entirely through a dense tough whinstone. Mr Milroy subsequently acted as agent for Mr Brassey and for Messrs. Brassey & Mackenzie in the construction of lines of railway of great extent on the Continent, the first of them being the Paris and Rouen Railway, with the late Mr Joseph Locke as the engineer-in-chief. He was also engaged in the same capacity on the Rouen and Havre, the Nantes and Caen, and the Caen and Cherbourg railways. A few years later Mr Milroy likewise served Mr Brassey as his agent in the construction of well-nigh eighty miles of the Great Northern Railway; and there were various other railway undertakings with which he was connected, not only in this country, but also in France and Italy; indeed, a considerable portion of his life was spent on the Continent, where he became exceedingly well known and greatly esteemed on account of his personal character. About a quarter of a century ago, Mr Milroy settled down in his native country, in order to take charge of some large works in which he was interested, along with the eminent firm with whom he had been already associated for about twenty years. The chief of those works was the construction of the City of Glasgow Union Railway, from the plans of Mr (now Sir) John Fowler. It included some difficult pieces of constructional work to connect the Glasgow and South-Western Railway on the south of the Clyde with the North British system of railways on the north side. There was also a very important iron girder bridge across the Clyde, together with the Sighthill Railway and the Harbour Railway running past Pollokshields and under a public roadway, a canal, and two other lines of railway. While engaged in sinking the cylinders for the viaduct over the Clyde, Mr Milroy brought into use a new excavator of his own invention, which subsequently did much excellent service in the construction of subaqueous works. While in and about Glasgow the deceased was induced to take two important contracts on his own account, two pieces of work involved in the extension of the harbour of Glasgow, namely, Plantation and Mavisbank Quays. In the former of these works, the superstructure was built on foundation piers which were formed of successive rings of brick-work, according to the plans of Mr James Deas, engineer to the Clyde Trust. In the construction of Mavisbank Quay, a marked improvement was made in the character of the subaqueous pier foundations, which were formed of concrete, the piers being most securely bound together. The Milroy excavator was here used to excellent purpose, enabling the piers to sink to depths of 50 ft. to 60 ft. or 70 ft. In these harbour works Mr Milroy was closely associated with Mr Deas, and he had as his right-hand man Mr George A. Waghorn, who also saw much service under Mr Brassey's firm. The various works which he carried out in the Glasgow district, including those for which he was the sole contractor, cost nearly 1½ millions sterling.

After having retired from active life, Mr Milroy passed his remaining years on the estate of Torsonce, which he acquired in the year 1879, and on which he occupied his time in making considerable improvements by building, roadmaking, &c. At his death he was eighty years of age. He was of a most retiring disposition, and when not occupied in superintending the improvements on his estate, devoted the last years of his life to the study of those branches of science which were most closely connected with his profession. He was elected a Fellow of this Society in 1875.

GENERAL SIR JAMES EDWARD ALEXANDER, Kt., C.B., K.C.L.S., &c.

General Sir James Edward Alexander, of Westerton, Stirlingshire, who was born in Stirling on the 16th October 1803, and whose decease took place at the Isle of Wight 2nd April 1885, was a collateral descendant of the family of the first Baronet, William Alexander of Menstrie, afterwards Earl of Stirling.*

After passing through the College of Edinburgh and Glasgow, he proceeded at an early age to India to join his relative Sir Thomas Munro, then governor of Madras. He there devoted himself to the study of Oriental languages, passed the required examinations, and was appointed to the Madras Light Cavalry, and adjutant of the governor's body guard. He was afterwards transferred to the 13th Light Dragoons in January 1825, and volunteering for active service proceeded to Burmah, was present in the field, and took part in the first Burmah war.

After the peace his acquirements were recognised by his being appointed attaché to the Persian Mission, under Sir John Macdonald Kinneir; while acting with the Persian army on the field against the Russians, he so distinguished himself that he received the Order of the Lion and Sun.

In consequence of his proficiency in Eastern languages and general attainments, he was offered, on return to England, a professorship at the College of Heylebury, but, declining this employment, he instead joined the senior department of the Military Staff College, obtained a first-class certificate, and shortly afterwards was promoted to a lieutenancy in the 16th Lancers. He then obtained a year's leave of absence, to enable him to complete his military studies, and to join the Royal Engineers at Chatham, under Sir Charles Paisley.

He next saw service with the Russian army of Field-Marshal Diebitch, then engaged in operations against the Turks. At the conclusion of this service, and while on his return to England, a slightly untoward incident occurred to him. Proceeding in a Russian frigate by way of Sebastopol, he was there placed in quarantine, in consequence of some cases of the plague having appeared on board. The port chanced to be visited at the time by H.M.S. "Blonde," commanded by Captain, afterwards Sir Edmund and Lord Lyons (commander-in-chief of the fleet during the Crimean war), then cruising in the Black Sea. Captain Lyons alone was allowed to land at the quarantine station, when he naturally communicated with his fellow-countryman. On the departure of the "Blonde," Sir James Alexander was immediately arrested by the Russian authorities, on suspicion of being an emissary of the British Government. He was arbitrarily confined two months in Sebastopol with other prisoners, and finally, in the depth of winter, sent under guard to St Petersburg, where, after undergoing further confinement and hard treatment, he was at length, by the intervention of the British ambassador, released, but without compensation for the unjust usage he had received—only a slight apology from the Emperor Nicholas in person.

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* He was buried in the old Logie kirkyard, near Menstrie.

He returned to England by Sweden and Denmark, and in recognition of the valuable information, plans, and reports he was enabled to furnish with regard to Russia and Turkey, he was promoted to an unattached captaincy.

Sir James was now selected by the Colonial Office to undertake an important commission of inquiry into the state of slavery in North and South America, receiving from the Secretary of State letters and credentials to the various governors of provinces, &c. On the conclusion of this mission he was examined before a committee of the House of Lords, by whom his able report was highly appreciated.

He shortly afterwards returned to full pay, and joined as a captain the 42nd Highlanders (Black Watch). While serving with this regiment, he was invited by the Royal Geographical Society to make explorations in Africa, and readily accepted a duty so congenial to his active and enterprising character; but the British expedition then being in the field against Don Miguel, he took the opportunity it afforded him of seeing further active service and acquiring further geographical knowledge by joining the expeditionary force. His effective service was rewarded by receiving from Don Pedro the rank of lieut.-colonel. He then proceeded on his mission in H.M.S. "Thalia" round the west coast of Africa, visiting the different settlements.

On arrival at the Cape, finding the war with the Caffres already commenced, and the time accordingly unfavourable for explorations, he joined the troops in the field under Sir Benjamin D'Urban, by whom he was appointed aide-de-camp. At the conclusion of the war, Sir James Alexander resumed his mission of exploration, and proceeded into the interior, accompanied only by seven men—encountering successfully the dangers, difficulties, and hardships to which at that time travellers in South Africa were subjected. In one year he accomplished 4000 miles, and completed a full report of the countries of the great Namaquas, Boshmans, and Hill Damaras.

On returning to England, Sir James E. Alexander received the honour of knighthood for his services in Africa, being the first knight created by the Queen in person after Her Majesty's accession. His African duties had obliged him to go temporarily on half pay; but he returned shortly to full pay as a captain in the 14th Regiment, then serving in North America. There he was asked to undertake and accepted the arduous duty of exploring and surveying in the construction of a military road through the forests of New Brunswick and Canada from Quebec to Halifax, acting as assistant royal engineer on this most trying service during 1844–45. He received no promotion or reward, beyond a slight addition to pay while so engaged, for this arduous service which he had been invited to undertake.

On Sir Benjamin D'Urban being appointed commander of the forces in Canada, he immediately reappointed Sir James as his aide-de-camp, a post he retained until Sir Benjamin's death in Montreal. Sir William Rowen succeeding to the command, he was again offered the aide-de-campship, and served on the staff of that distinguished officer for 5½ years. He rejoined his regiment as major on the breaking out of the Crimean war, shortly became lieut.-colonel, and succeeded to its command during the siege of Sebastopol, at the fall of which stronghold he was present.

During this time of scarcity and hardship, his regiment was notorious for the beneficial arrangements for their supply and comfort that his previous experience on active service had enabled him to make for the comfort and welfare of his men.

Sir James Alexander was next appointed to the command of a depôt battalion, but was shortly selected to raise the 2nd battalion of his old regiment, the 14th; this he so quickly did, and so rapidly brought them into an effective state, that his battalion was the first of the new 2nd battalions that proceeded on service in the field; this was to New Zealand, to engage in the Maori war. Here he commanded for some time in the province of Taranaki, and under Sir Duncan Cameron the important outposts at Waikato.

He was then promoted to major-general in 1868, lieut.-general in 1877, and general in 1881. He received during his service seven war medals, but the reception only of the C.B. (3rd Class of the Order of the Bath) will be considered but an inadequate acknowledgment of long and arduous service.

Sir James Alexander was the author of various works of travel and of a biographical and military character, such as his *Life of the Duke of Wellington*, *Canada as it is*, &c., *Passages in the Life of a Soldier*, and others relating to the various countries with which he was personally acquainted, as well as the contributor of numerous articles in periodicals on the military, scientific, and social topics of the day.

The deep interest he took in all questions relating to the interests and improvements of the army, especially as regarded its equipments, and his untiring exertions in promoting these objects to the utmost of his power, are well known. He was among the foremost and most strenuous supporters of those who called public attention to the long-neglected justice of granting medals for the Peninsular services of the army, hitherto unrecognised by distinctive decorations. This movement was eventually carried to a successful result, through the influence and advocacy of the Duke of Richmond in the House of Lords, and with the military authorities, was much indebted to the indefatigable exertions of Sir James Alexander.

Mainly also to his exertions may be truly attributed the ultimate erection of the Egyptian obelisk (called Cleopatra's Needle) in its present site on the Thames Embankment. This obelisk, presented by Egypt to England in recognition of the services of the British army in Egypt under Abercrombie, owing to untoward circumstances which prevented its shipment to England, for which arrangements had been made at the expense of the army, was allowed from that up to the present to lie neglected on the shore of Alexandria harbour, at the point intended as that of embarkation; and the English Government having refused to incur the expense of its removal, it would finally have been broken up in 1874, had not Sir James Alexander, who had long endeavoured to call public attention to the matter, personally interfered, and undertaken at his own expense a voyage to Alexandria, and, with the aid of the British consul-general, succeeded in rescuing it from destruction. On his return he renewed his exertions, so many years unsuccessful, and obtained the munificent pecuniary assistance of Sir Erasmus Wilson, by which after great difficulties the obelisk was transported to England and erected in its present site. The country must be considered indebted to Sir James Alexander's persevering energy for its possession of this most valuable and interesting antiquity.

It would be difficult to enumerate the various other works of public and private character, whether in England or abroad, in which he was constantly engaged, and bore a leading and prominent part; these will long be gratefully remembered by those who benefited by his exertions.

Of him may truly be said, that in all countries whatever good work he found at his hand to do that he did with heart and soul; and in him those who had the privilege of his acquaintance recognised that highest type of character, the single-hearted, high-minded Christian gentleman, whose life was devoted to duty and to the promotion of the interest and welfare of his fellow countrymen, and the communities among whom his lot might be more immediately cast.

ALEXANDER JAMES RUSSELL, C.S.

Mr Alexander James Russell, Clerk to Her Majesty's Signet, Edinburgh, who died recently—8th January 1887—at the age of seventy-two, was head of the firm known formerly as Russell & Nicolson, C.S., and latterly as Russell & Dunlop, and the business which he carried on was one of the oldest in Edinburgh, dating back to the end of the seventeenth century, and having descended in the direct line from father to son.

His father, Mr John Russell, was principal Clerk of Session, and

Secretary of the Royal Society of Edinburgh, and his great-great grandfather was solicitor for the sale of the forfeited estates in Scotland after the Rebellion of 1715, and one of the original shareholders of the Bank of Scotland. On his mother's side, Mr Russell was closely related to the ancient Scottish family of Murray of Polmaise, his mother having been the daughter of the late Mr Murray of Polmaise, and he was a great-grandson of Principal Robertson, the Scottish historian. He was for many years a director of the National Bank of Scotland and of the Standard Life Assurance Company, and for some time latterly solicitor to that Company. In politics he was a Conservative, but he did not take any active part in political life. Mr Russell was married—first, to Miss Magdalene Stein, daughter of the late Andrew Stein, Esq. of Wester-Greenyards, Fifeshire, and secondly, to Miss Elizabeth Anne Lancaster, daughter of the late Samuel Lancaster, Esq. of Hemborough, Devon, who now survives him. He left also an only son, Colonel J. Cecil Russell, late of the 12th Lancers, and for some time an equerry to the Prince of Wales.

PROCEEDINGS

Ac. 3034

OF THE

ROYAL SOCIETY OF EDINBURGH.

SESSION 1886-87.

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